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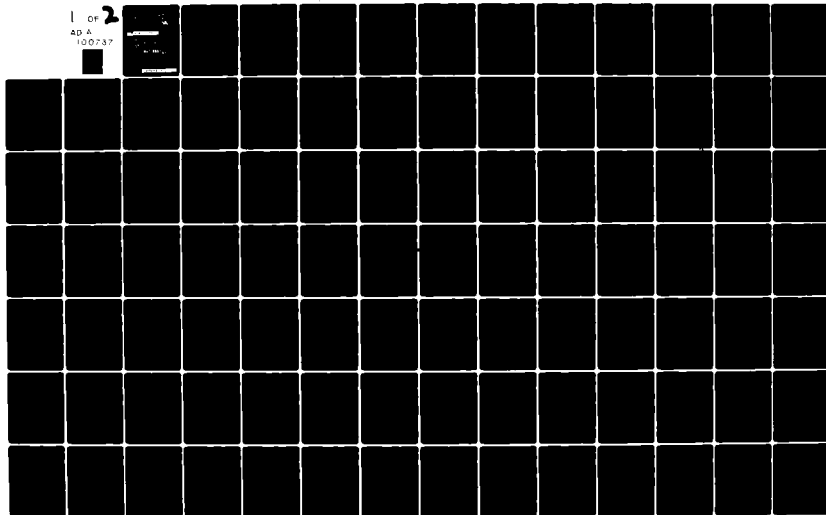
CORPS OF ENGINEERS BUFFALO N Y BUFFALO DISTRICT
REVIEW OF REPORTS ON LAKE ERIE-LAKE ONTARIO WATERWAY, NEW YORK.--ETC(U)
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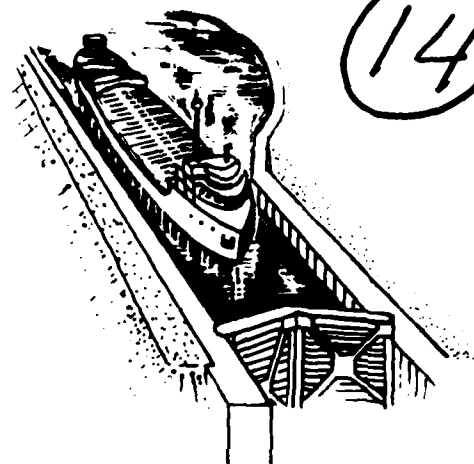
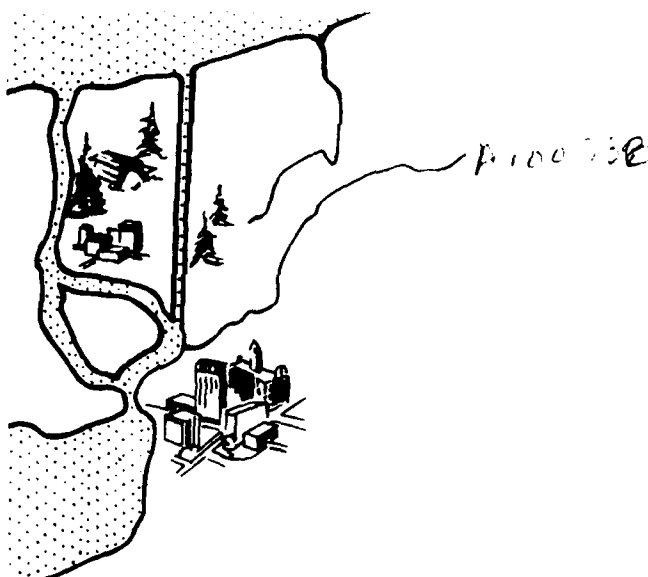
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REVIEW *of* REPORTS

on LAKE ERIE-LAKE ONTARIO WATERWAY N.Y.

MAIN REPORT



U.S. ARMY CORPS OF ENGINEERS
BUFFALO DISTRICT

OCTOBER 1973

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this review is to examine the conclusions from the environmental, engineering and economic studies of the construction of a water way between Lake Erie and Lake Ontario in the United States. This report will also serve as a basis for further action by Congress.		

SYNOPSIS

The present connection for deep-draft vessels between Lake Erie and Lake Ontario is the Welland Canal, in Canada, completed in 1932. Traffic through the canal increased appreciably when the St. Lawrence Seaway was opened. The traffic is expected to continue to increase at such a rate that, in about 1990 (dependent on the general economic conditions at the time), it will exceed the practical capacity of the canal. The additional capacity that will be needed could be supplied by the Lake Erie-Lake Ontario Waterway (LE-LO) located in the United States. This study indicates that such a waterway would cause no significant ecological damage and would be practical from an engineering standpoint. However, the economic justification of the waterway is lacking when based solely on United States transportation savings from waterborne commerce over alternative modes.

It is estimated that a new waterway in the United States could be constructed at a first cost of \$2,237,600,000 with annual charges of \$176,116,000. Estimated annual benefits resulting from savings in transportation costs are \$76,500,000. The benefit-cost ratio, considering only United States transportation savings is 0.4 to 1. Benefits that might occur from other uses of the waterway, Canadian transportation savings, recreation, or from possible increased industrial and commercial development stimulated by the construction of the waterway, are not included in this benefit-cost ratio.

A principal conclusion of the computer simulation of traffic through the existing Welland Canal is that traffic between Lake Erie and Lake Ontario will be constrained in about 1990 unless major structural changes to the Welland Canal are made or a parallel canal is provided. Any improvements between Lake Erie and Lake Ontario should be considered a part of the entire Great Lakes-St. Lawrence Seaway navigation system. Before improvements are made to one portion, the effects on the total system must be considered. For example, the majority of Lake Erie-Lake Ontario transits are of a through-traffic nature and utilize the St. Lawrence Seaway. Improvements to increase the capacity of Lake Erie-Lake Ontario navigation will result in a traffic capacity problem on the St. Lawrence Seaway in the near future. In order to do a systems analysis of the Great Lakes-St. Lawrence System, a joint effort between the United States and Canada is required.

X

A

GREAT LAKES-ST. LAWRENCE RIVER DRAINAGE SYSTEM

SCALE OF MILES

1:100,000

1:250,000

1:500,000

1:1,000,000

1:2,000,000

1:4,000,000

1:8,000,000

1:16,000,000

1:32,000,000

1:64,000,000

1:128,000,000

1:256,000,000

1:512,000,000

1:1,024,000,000

1:2,048,000,000

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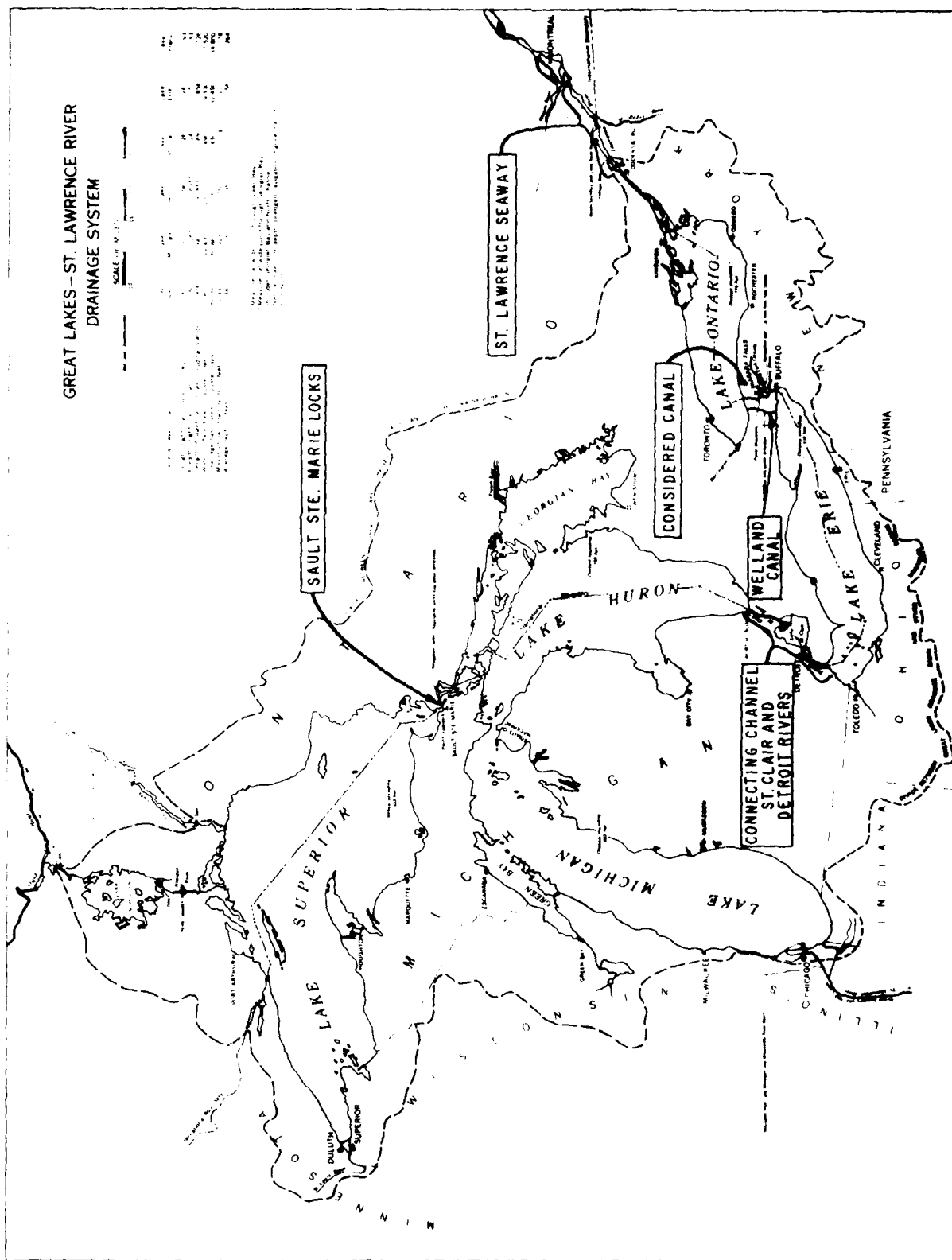
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REVIEW OF REPORTS
ON
LAKE ERIE - LAKE ONTARIO WATERWAY, N.Y.

MAIN REPORT

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13.	Black Rock Channel and Tonawanda Harbor
14.	Black Rock Ship Lock
15.	Niagara River

PURPOSE AND AUTHORITY

1. Purpose. The purpose of this review of reports is to examine the conclusions from the environmental, engineering, and economic studies of the construction of a waterway between Lake Erie and Lake Ontario in the United States. The report will also serve as a basis for further action by Congress.

2. Authority. The Review of Reports on Lake Erie-Lake Ontario Waterway, NY is submitted in compliance with resolutions of committees of the United States Congress as follows:

a. Resolution adopted 6 May 1958 by the Committee on Public Works of the United States:

"RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on the Great Lakes and connecting waters including Niagara River, published as House Document Numbered 253, Seventieth Congress, First Session, and other reports, with a view to determining whether any modification of the recommendations contained therein is advisable at this time, with particular reference to construction of an All-American Waterway connecting Lake Erie and Lake Ontario."

b. Resolution adopted 16 July 1958:

"RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports of the Chief of Engineers on the Great Lakes and connecting waters, including Niagara River, published as House Document Numbered 253, Seventieth Congress, First Session, and other reports, with a view to determining whether any modification of the recommendations contained therein is advisable at this time, with particular reference to construction of an All-American Waterway connecting Lake Erie and Lake Ontario."

c. Resolution adopted 24 August 1961:

"RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors be, and is hereby requested to review the reports on Black Rock Channel and Tonawanda Harbor, New York; Buffalo Harbor, New York; and Niagara River, New York; with particular reference to the reports on Black Rock Channel and Tonawanda Harbor printed in House Document numbered 423, Eighty-third Congress, second session, with a view to determining if the existing projects should be modified in any way at this time."

d. Resolution adopted 11 December 1969:

"RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Great Lakes and Connecting Waters, including Niagara River, published as House Document Numbered 253, Seventieth Congress, First Session, and other reports, with a view to determining whether any modification of the recommendations contained therein is advisable at this time, with particular reference to providing deep draft harbor facilities on the north shore of Niagara County, New York, and to otherwise accommodate present and future commerce."

DESCRIPTION OF PROJECT AREA

3. Location. The canal route is located in Erie and Niagara Counties in the western part of New York State (refer to map on Plate 1). These counties occupy the land area lying between Lakes Erie and Ontario and immediately east of the international boundary. The east end of Lake Erie and the west end of Lake Ontario are generally parallel, 20 to 30 miles apart. Between the lakes, the land rises gradually northward from Lake Erie to the crest of the Niagara Escarpment at elevations varying from 600 to 700 feet above sea level. North of the crest, the escarpment drops sharply in one or more steps to elevations varying from 340 to 420 feet above sea level. The land then slopes gradually to Lake Ontario. The outlet of Lake Erie is the Niagara River, which starts at the northeast corner of the lake, flowing northward to Lake Ontario.

4. Niagara River. The Niagara River carries the outflow of the upper Great Lakes seaward from Lake Erie to Lake Ontario. It drops from a mean elevation of 570.4 feet above sea level at Lake Erie to 244.8 feet above sea level at Lake Ontario. This drop of 325.6 feet and its great discharge are primarily responsible for giving the river its unique character. The total length of the river is 36 miles, but because of the nature of the geology of the region, most of the drop occurs in an 8-mile distance between Chippawa and Queenston, about half at the Falls and an additional 140 feet in the rapids above and below the Falls.

The Falls of the Niagara and its surroundings constitute one of the scenic wonders of the world, exciting the awe and admiration of all beholders. For more than two centuries they have been attracting visitors from every part of the globe in ever-increasing numbers.

A 1929 report estimated annual visits at about 2,000,000 during the latter part of the 1920's. Recent figures for attendance are close to 10,000,000 including both sides of the border. With the constant increase of tourist travel, a continuing expansion of tourism at the Falls may be expected.

5. Upper Niagara River. The Niagara River flows north out of the northeast corner of Lake Erie. For the first two miles, it is little more than 1,500 feet wide, and velocities are as high as eight miles per hour. The river then widens to about 2,000 feet for the next two miles to the foot of Squaw Island (See Plate 13). Below the island, the river widens considerably and the current decreases. Two miles

below the island, the river is divided into two channels by Grand Island, the Canadian Channel being 10 miles long and the American or Tonawanda Channel about 13 miles long. The four miles of river from the lower end of Grand Island to the head of the Cascades, opposite the upstream end of Goat Island, is known as the Chippawa-Grass Island Pool. Here the river flows in a westerly direction. Principal hydroelectric power plant intakes are located on this pool. On the Canadian side, near the downstream end of the pool, the Niagara River control structure extends out into the river at right angles to the shore for 2,000 feet. With the exception of an approach fill adjacent to the shore, it consists entirely of piers and 18 movable control gates.

6. Bridges. (See Plate 13) Existing bridges across the Black Rock Canal and the upper Niagara River downstream of the Black Rock Lock are listed in the following table.

TABLE 1. - BRIDGES

Name and ownership	Use	Distance downstream of south entrance to canal (miles)	Type	Clear height above LWD (feet)(1)	Clear span over deep- draft navi- gation channel (feet)	Date of approval of plans by Department of the Army
BLACK ROCK CANAL						
*Peace Bridge	Highway	2.00	Fixed	100.3	200 (2)	August
Buffalo and Port Erie Public Bridge Authority						1925
Ferry Street City of Buffalo	Highway	2.60	Bascule	17.3	149	(3)
*International Bridge Canadian National Ry.	Railroad	3.75	Swing	17.0	162	September 1909
NIAGARA RIVER						
South Grand Island Bridges, NY State	Highway	9.25	Fixed	99.0(4)	400	July 1933 Oct 1957
Thruway Authority						(5)

(1) Above Low Water Datum with bridge closed.

(2) Pier to pier distance is 334 feet.

(3) Built as U.S. Government structure, completed 1914, City of Buffalo assumed operation in October 1953.

(4) At piers, vertical clearance is 27.5 feet; pier to pier distance is 588 feet.

(5) Twin parallel bridges, upstream bridge built first.

* These bridges also cross the Niagara River.

7. Terminal and Transfer Facilities. (See Plate 12) Buffalo Harbor has an extension system of terminals to handle the waterborne commerce in iron ore, limestone, grain, petroleum products, and other bulk and general cargo. Most of the docks are private and operate in connection with industrial or commercial installations. The Niagara Frontier Transportation Authority operates some public docks in the outer harbor, handling general cargo, and a variety of bulk cargo, including import-export traffic. The terminals are adequate for existing traffic, and frontage is available for expansion. The terminals would not be adversely affected by the considered waterway.

Terminal and transfer facilities along the Black Rock Channel and Tonawanda Harbor project are located along the Niagara River section and the Tonawanda Harbor area. They handle primarily coal and petroleum products and a few other miscellaneous commodities; they are all privately owned and operated; and they are considered adequate for existing commerce with room for expansion. Along the Niagara River, a popular recreational boating area, are a considerable number of marinas and yacht clubs. None of the commercial or recreational installations would be adversely affected by the considered waterway.

A city-owned dock at Niagara Falls is the only commercial terminal along the Niagara River project. It is used for receipt and shipment of bulk chemicals and is considered adequate for the modest commerce using the project. The dock would not be affected by the considered waterway.

8. Flow in the Niagara River. The average flow in the Niagara River is about 202,000 cubic feet per second. This large discharge, combined with the relatively uniform flow resulting from the large amount of storage in the upper lakes, has made the river attractive for hydro-electric power development. In order to provide for the maximum development of power and still preserve the scenic beauty of the Falls, the United States and Canada adopted the Treaty of 1950, which requires that certain minimum flows over the Falls be maintained. The treaty requires in general a minimum flow of 100,000 cubic feet per second (cfs) over the Falls during the daylight hours of the tourist season and 50,000 cfs during the remaining hours. It was found that flows could be reduced to these levels without significant diminution of the scenic beauty of the Falls. The control structure was constructed as a result of this treaty in order to compensate for the large power diversions, maintain natural levels in the upper Niagara River, and expedite the twice daily changes in flow over the Falls.

9. Overland Section. (See Plate 1) The overland section of the considered waterway route comprises the area from the Niagara River at North Tonawanda extending northerly to Lake Ontario. From the Niagara River, the land slopes gradually upward for about three miles to the vicinity of Bergholtz, then rises more abruptly from about 580 feet above sea level to about 630 feet above sea level in a distance of 1-1/2 miles. The ground remains at about this elevation to the crest of the Niagara Escarpment, another three miles just westerly of the community of Pekin. The ground then drops rapidly crossing the escarpment. The drop is in two steps separated by a

small level area. The first drop, from 630 to 540 feet above sea level, occurs in a distance of about a quarter of a mile. The level area is about 3/4 mile wide. The next drop, from 540 to 390 feet above sea level, comes in a distance of another 3/4 mile. From the foot of the escarpment, the ground slopes to the lake in about seven miles. The bluff at the lake shore is about 20 feet high.

Near the river, there is considerable development. A City of North Tonawanda park along the immediate river bank is a day-use facility with picnic tables, playground equipment, and a launching ramp. Immediately inland is River Road, an important local route between North Tonawanda and Niagara Falls. Paralleling the highway are the important freight railroad lines of the Penn Central Transportation Co. and the Erie-Lackawanna Railroad, connecting Buffalo and Niagara Falls.

North of the railroads, the route passes through an open area used for farming and also the site of a Niagara County solid waste disposal facility. The area east of the considered canal is well-developed for residential purposes. About 2-1/2 miles from the river, the route crosses Niagara Falls Boulevard, an important through route. Just north of the road is Oppenheim Park, owned by Niagara County. It is extensively developed as a day-use facility. North of the park, the route passes just to the east of the small community of Bergholtz.

North of Bergholtz to the escarpment, the route passes through areas used for farming. About three miles north of Bergholtz, the route passes west of the community of Sanborn. In this stretch, the

route crosses Saunders Settlement and Lockport Roads, both important local roads and also major highways between Niagara Falls and Lockport. Here the route also crosses the important Niagara Falls-Rochester freight line of the Penn Central Transportation Co. At the crest of the escarpment, it crosses Upper Mountain Road, an important local service road.

North of the escarpment, the route lies primarily through farm land. It passes west of the community of Ransomville. Major highways crossed include Ridge Road, the principal route paralleling the south shore of Lake Ontario, and the important local routes of Deckersonville Road, Youngstown-Lockport Road, Youngstown Road, and Lakeshore Road. The latter is the principal road serving the lake-shore cottages. There is also one railroad crossing, a lightly-used freight branch of the Penn Central.

10. Population. Along the route of the canal are three cities, one large town, and four unincorporated hamlets. Buffalo is the largest city. The other two cities are Tonawanda in Erie County and North Tonawanda in Niagara County. Unincorporated hamlets in Niagara County are Bergholtz in the town of Wheatfield, Sanborn and Pekin in the townships of both Cambria and Lewiston, and Ransomville in the town of Porter. In Erie County, the town of Tonawanda is a large population center with the characteristics of a city in all but name. While not directly along the route, the cities of Niagara Falls and Lockport are near and would be influenced by the waterway.

The 1970 population figures for counties and principal towns and cities in the study area are as follows:

Erie County - Total	1,113,000
Buffalo - City	463,000
Tonawanda - City	22,000
Tonawanda - Town	107,000
Niagara County - Total	236,000
North Tonawanda - City	36,000
Wheatfield - Town	9,700
Lewiston - Town	16,000
Porter - Town	7,400
Lockport - City	25,000
Niagara Falls - City	86,000

11. Economic Development. In the two-county area, manufacturing is the predominant economic activity. Principal manufactures are iron and steel, automotive parts, chemicals, machinery, printing, paint, and electrical products. While considerable portions of land are used for agriculture, this sector plays a small part in the overall economy of the area. The area, especially Buffalo, serves as a regional trade and financial center for much of Western New York and is a transportation hub, especially for traffic with Canada. Further information on area economic activity will be found in Appendix E.

12. Existing Waterway. The present Welland Canal begins at Port Weller on Lake Ontario about 7-1/2 miles west of the mouth of the Niagara River and extends to Port Colborne on Lake Erie. The canal is 27.6 miles long with a prism generally 200 feet wide at the bottom and 310 feet wide at the water surface. The present depth is 27 feet with a permissible vessel draft of 25.5 feet. There are 8 locks, consisting of one guard lock about 1½ miles north of the Lake Erie entrance at

Port Colborne, and 7 lift locks located in the northern 1/3 of the total length at and below Thorold. The lifts vary from 43.7 feet to 47.9 feet with a normal total lift of about 327 feet. Depth over the lock sills is 30 feet, and the inner dimensions are generally 800 feet long and 80 feet wide. The guard lock, No. 8 at Port Colborne, is 1,380 feet long and 80 feet wide.

The usable length within the lock chamber is determined by the distance between the fender boom and the lock gate at the other end of the lock. These movable fender booms are lowered across the lock chamber to protect the lock gates. There are normally 3 fender booms at each lock, one downstream of the lower gate, one immediately upstream of the lower gate, and one upstream of the upper gate. No fender boom is required downstream of the upper gate as the breast wall of the lock protects the upper gate from upbound vessels. These fender booms determine the normally usable length of the lock. Vessels up to 715 feet in length can be accommodated in the locks with the fender booms lowered in their normal operating position. Vessels up to 730 feet in length and 75 feet in width can pass through the Welland locks; however, special handling is required. Vessels of this size upbound do not require any particularly difficult handling. However, when the vessel has reached the upstream limit of the lock, the fender just upstream of the lower gate cannot be lowered due to the length of the vessel. Handling of downbound vessels is more of a problem. A 730-foot vessel enters into the lock normally and proceeds to the boom just above the lower gate. The vessel is then brought to a complete stop.

The fender boom is raised, and the vessel is moved ahead by its winches alone. This adds several minutes to the ordinary lockage time.

Locks No. 4, 5, and 6 are twin sets of locks in flight between Merritton and Thorold, overcoming the steep rise of the Niagara Escarpment and permitting uninterrupted passage of upbound and downbound traffic. These locks are continuous; that is, the lock chamber of one lock joins the chamber of the next upper one and shares a common gate. Each set of the three locks may pass vessels in either direction. However, once a ship has entered one side, it must continue on that side through the three locks as it cannot cross over to the opposite side, if such a shift was otherwise desirable, due to the prevailing pattern of traffic. This factor has a major effect upon the capacity of the canal, because once a ship has moved from one of the locks into the next, the lock behind it must go through a dummy lock cycle to return the water level to its original position to accommodate the next ship moving in the same direction.

Locks No. 1, 2, 3, 7, and the guard lock No. 8 are single locks at the present time. Ship passages normally alternate between upbound and downbound, but may be varied to meet traffic demands.

The canal is crossed by 12 bridges, four of which are railroad bridges and the remainder highway bridges. The overhead clearance above normal water surface is 120 feet. It is governed by the vertical lift bridges and one fixed highway bridge. The width between fenders of most of these bridges is 200 feet. In addition to the bridge crossings, two highway and one joint rail-highway tunnel pass under the canal.

In the summer of 1963, the Canadian Government announced plans for further improvement of the Welland Canal to eliminate congestion that it felt would become acute without further improvement. No new locks have been constructed since then; however, new tie-up walls have been provided, lock operating machinery modernized, surge basins installed in critical sections, operating procedures revised, an extensive traffic monitoring and control system installed, and a new by-pass constructed. These features have increased greatly the traffic capacity of the waterway.

13. Existing Navigation Season. During the winter, ice season months, interlake and overseas navigation is suspended on the Great Lakes. The average navigation season for the Welland Canal is 263 days. However, for overseas traffic, the navigation season is controlled by conditions in the St. Lawrence Seaway which limit use of the Welland Canal by overseas traffic to approximately 245 days.

DESCRIPTION OF GREAT LAKES-ST. LAWRENCE WATERWAY SYSTEM

14. Introduction. The Great Lakes and St. Lawrence River provide a continuous waterway extending 2,300 miles into the heart of the North American Continent. For geographical reasons and in order to bring out the different responsibilities for the waterway system both nationally and internationally, the St. Lawrence River - Great Lakes Waterway is described in four parts: (1) the Gulf of St. Lawrence and the lower St. Lawrence River; (2) the upper St. Lawrence River between Montreal and Lake Ontario; (3) Lake Ontario and the Welland Canal connecting Lake Ontario and Lake Erie, and (4) the upper Lakes

and connecting channels that include the waterways between Lakes Erie and Huron, Lakes Huron and Superior, and Lakes Huron and Michigan. Table 2 lists pertinent details of the Great Lakes - St. Lawrence Waterway System.

15. Gulf of St. Lawrence and Lower St. Lawrence River. The Gulf of St. Lawrence extends from the Atlantic upstream 700 miles to Father Point, Quebec. Two entrances to the St. Lawrence are available from the Atlantic, one through the Strait of Belle Isle to the north of Newfoundland, which provides a 12-mile wide passage at its narrowest point, and another south through the Cabot Strait, which provides a 60-mile wide passage south of Newfoundland.

The St. Lawrence River begins at Father Point, and in the 340 miles to Montreal, it ascends only 20 feet from sea level. The tidal run dissipates about halfway between Montreal and Quebec City around the city of Trois-Rivieres. The Canadian Government maintains a 35-foot channel in the thousand miles between the Atlantic and Montreal. The annual cost of this operation has been financed by the Canadian Government.

16. The Upper St. Lawrence River. The reach between Montreal and Lake Ontario, a distance of 182 miles, ascends a total of 226 feet, thus presenting the greatest obstacle to navigation along the upper St. Lawrence River. On the other hand, it offers the greatest potential for hydroelectric power development. Rapids and lakes stretch alternately through this section of the river.

The Lachine Rapids are bypassed by a lateral canal 18 miles long containing two locks, the St. Lambert Lock at the lower end opposite

Table 2

DETAILED DESCRIPTION OF THE GREAT LAKES-ST. LAWRENCE SEAWAY

Reach	Distance in Miles				Locks			
	Open Waters	Channels & Canals	Depth (min)(ft)	Number	Year Completed	Size (feet): Length x Depth	Depth over (Sill)(Ft)	Lift
Gulf of St. Lawrence:	700	-	-	-	-	-	-	-
St. Lawrence River								
Father Point to Montreal	340	-	35	-	-	-	-	-
Montreal to Lake Ontario	148.5	34.5	27	7	1958	800x80	30	226
Lake Ontario St. Lawrence River thru Welland Canal	182	30	27	8	1932	800x80	30	326
Lake Erie, Welland Canal to Detroit River	218	-	27	-	-	-	-	-
Detroit River	-	31	27	-	-	-	-	-
Lake St. Clair	-	17	27	-	-	-	-	-
St. Clair River	-	40	27	-	-	-	-	-
Lake Huron, Point Detour to St. Clair River	223	-	-	-	-	-	-	-
St. Mary River to Point Detour	61	2	27	4	(2)1919 (1)1943 (1)1968	1350x80 800x80 1200x110	23.1 31.0 35.0	22 22 22
Lake Superior, Duluth to St. Marys River	383	-	-	-	-	-	-	-

Montreal and the Cote Ste. Catherine Lock 8-1/2 miles upstream.

Lake St. Louis extends upstream another 16 miles to the point where the Ottawa River joins the St. Lawrence River. Continuing upstream, a series of rapids known as the Cascades, Split Rock, Cedar, and Coteau rapids form a total ascent of 82 feet between Lake St. Louis and Lake St. Francis. The rapids in this section of the river are bypassed by a lateral canal 2-1/2 miles long containing two locks, the Upper and Lower Beauharnois Locks. Beyond this, the artificial channel continues upstream for a distance of 14 miles via the Beauharnois power canal that terminates in Lake St. Francis. This section of the river, including Lake St. Francis, is in Canada.

The international section of the river begins at the upstream end of Lake St. Francis. This formerly was a swift-flowing section that ascended 50 feet in a distance of 44 miles to Ogdensburg, New York. Instead of the rapids and swift flowing river, this section is now a reservoir and is held back by four power structures, forming Lake St. Lawrence. The difference in elevation for navigation is overcome by three locks, the Bertram H. Snell, the Dwight D. Eisenhower, and the Iroquois.

The remaining section of the river, the Thousand Islands section, extends 40 miles to Lake Ontario. Although free of rapids this section still contains rock shoals that were an obstruction to navigation. These have been removed, and the channels have been widened and straightened for navigation.

The controlling channel dimensions for the Seaway, Lake Erie to Montreal, are a minimum depth of 27 feet, to permit transit of vessels drawing 25½ feet (fresh waterdraft) and widths of basically 600 feet in open river and 442 feet in canals.

The seven new locks of the St. Lawrence River (five in Canada operated by the St. Lawrence Seaway Authority of Canada and two in the United States operated by the St. Lawrence Seaway Development Corporation) are all similar in size. The locks are 800 feet long and 80 feet wide, with 30 foot depth over the sills. These locks can accommodate ships up to 730 feet in length and 75 feet in width. The upper St. Lawrence River section was opened to deep-draft navigation in 1958.

17. Lake Ontario and the Welland Canal. Lake Ontario, the smallest of the Great Lakes in area, is about 180 miles in length and 50 miles in width. The Welland Canal, 28 miles in length, provides a waterway between Lakes Ontario and Erie, bypassing Niagara Falls and the river gorge with a series of eight locks. The Welland Canal was designated a part of the Seaway by the Canadian Seaway Act and is now operated by the St. Lawrence Seaway Authority. The Welland Locks and Canal were completed by Canada in 1932.

Since the opening of the seaway, many improvements to reduce transit time through the Welland Canal have been undertaken. One important addition is the traffic control system inaugurated in 1966, which uses closed-circuit television and telemetry in directing ship

movements. A new eight-mile straight channel to bypass the part of the original route that is intersected by a number of highway and railroad bridges was opened to navigation in 1973.

18. Lake Erie and the Detroit River. Lake Erie, the fourth smallest of the Great Lakes, is the shallowest and most southerly located. The distance from Buffalo at the easterly end of the lake to Toledo at the westerly end is 241 miles, while the greatest width is about 57 miles. The western end of the lake is quite shallow, and navigation channels have been dredged out into the lake for many miles to provide adequate depth for vessels loaded to system draft.

The Detroit River connects Lake Erie with Lake St. Clair. The river has a length of about 32 miles. In this distance, the river ascends about 3 feet. The southern or lower river is broad and is characterized by many islands and shallow expanses; in this portion the banks are more flatly sloping than in the upper river, and the bottom consists generally of earth and boulders, with a few reaches of bedrock. The limitations imposed by the natural formation of the lower riverbed have necessitated very extensive rock excavation and dredging to provide channels of suitable width and depth for the large vessels now using the system.

For the northern or upper 13 miles, the river is of unbroken cross-section except for two islands directly at its head. In this reach, the water is generally deep, the bottom is of earth, and the channel banks are quite steep. There are two channels of approach to the Detroit River, the main channel from the east with a minimum depth of

28½ feet and a westerly channel toward Toledo with a depth of 22 feet. The main channel divides about 2½ miles upstream of the junction of the approach channels. One channel is used for upbound traffic, the other for downbound (toward Lake Erie). These are about 7 miles long. The channels then unite for another 8 miles to naturally deep water in the upper river. The minimum depth below low water datum is 27 feet, with greater depths in rock areas and exposed reaches. The minimum width in the dredged channels is 600 feet; in the northern section minimum width is 800 feet, passing the islands at the head of the river.

19. Lake St. Clair and St. Clair River. Lake St. Clair is an expansive shallow basin, having low and marshy shores and flatly sloping bottom formation, with a maximum natural depth of 21 feet below low water datum. A ship channel has been dredged entirely across the lake, with a depth of 27½ feet. It is 800 feet wide across the lake, with a 700-foot width at the mouth of the cut-off channel of the St. Clair River.

The St. Clair River, linking Lake St. Clair with Lake Huron, ascends about 5 feet. The river has two characteristic sections, the lower or delta portion and the upper or normal channel. The delta portion, commonly known as the St. Clair River Flats, is the land and water area at the lower end of the St. Clair River below Chenal Ecarte, Ontario, and formed by the division of the river into a number of distributaries. The most important branch, used for through navigation, is called the South Channel and connects Lake St. Clair with the main river through the St. Clair Cutoff Channel and is about 11 miles long. The upper channel runs from the head of the Chenal Ecarte to Lake Huron,

a distance of 28 miles. Depths throughout are at least 27 feet below low water datum. A considerable length of the river has had to be dredged to provide these depths. Minimum width at full depth is 700 feet.

20. Lake Huron. Lake Huron is the second largest of the Great Lakes. Length along the steamer track from head of St. Clair River to Straits of Mackinac is 247 miles, breadth is 101 miles. There are no large areas of shallow water to hinder navigation.

21. St. Marys River. The St. Marys River is the link between Lake Huron and Lake Superior. The distance along the main ship channel is 63 miles. There is a difference of about 23 feet in the elevation of the two lakes. Most of the drop occurs at the St. Marys Rapids (Sault Ste. Marie) about 15 miles from the head of the river. The drop here, about 22 feet, is overcome by five locks, four U. S. and one Canadian. The largest lock, the Second Poe Lock, is a U. S. lock and was completed in 1968. Its usable dimensions are 1,200 feet long, 110 feet wide, and it has a 32 foot depth over sills. The St. Marys River is winding, with considerable variation in widths and numerous islands and side channels. To obtain a minimum depth of 27 feet, it has been necessary to dredge channels almost the entire length of the river. Due to the winding and irregular nature of the river, separate channels had to be provided in many places for ships headed to and from Lake Superior. Minimum width in the channels is 600 feet.

22. Lake Superior. Lake Superior is the largest of the Great Lakes and also the most northerly. The steamer track length from head of St. Marys River to Duluth is 383 miles; width is 160 miles. The lake is generally deep, without any extensive shallow areas to hinder navigation; however, there are a number of isolated shoals that are hazardous to deep-draft navigation.

23. Straits of Mackinac and Lake Michigan. These Straits form the connection between Lakes Huron and Michigan. For the most part, the natural channel is wide and deep, but a few shoal areas have been dredged to provide depths comparable to depths in other connecting channels.

Lake Michigan is the third largest of the Great Lakes and the only one with a predominant north-south axis. The distance along the steamer track from the Straits of Mackinac to Chicago is 321 miles; the breadth is 118 miles. At the southern end of the lake, there is a barge connection with the Mississippi River System via the Illinois River. There are no extensive shoal areas, but there are scattered islands and shoals in the northern end that are hazardous to deep-draft navigation.

24. TRIBUTARY AREA AFFECTED BY PROJECT

The area expected to be served by the considered waterway includes the industrially oriented, but also agriculturally important, mid-continent of the United States. This area includes all or portions of the eight U. S. Great Lakes border states of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York, and an

additional eleven-state hinterland comprised of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Kentucky, and West Virginia. These 19 states make up the Great Lakes area of influence in the United States. In Canada, the area of influence includes the major industrial provinces of Quebec and Ontario, with the City of Montreal and the developing Ontario megapolis of Toronto and Hamilton. The Canadian areas of influence also include the Prairie Provinces, one of the world's great grain producing areas.

Table 3 illustrates the economic relationship of the nineteen-state Great Lakes service area in comparison with the total economic and demographic development in the United States. This nineteen-state area serviced by the Great Lakes has about 41 percent of the continental land area and 36 percent of the population of the continental United States. However, it accounts for about 44 percent of the value in manufacturing and for about 42 percent of capital expenditures. The important role of the area's agriculture is indicated by the fact that it accounts for half of the value of all farm products sold. These figures indicate that the nineteen-state area plays a major or even dominant role in the economy of the country.

TABLE 3. Land area, population and economic activity in the Great Lakes area compared to United States totals

Item	Great Lakes - Hinterland (2)			Great Lakes - Border States (2)	
	United States (1)	Number or Amount	Percent of U.S.	Number or Amount	Percent of U.S.
	(Number and percent of the U. S.)				
Land area, sq.mi., 1970 (3)	2,962,998	1,205,286	40.7	366,569	12.4
Population, 1970 (3)	202,112,686	73,144,566	36.2	52,428,512	25.9
Manufacturing - 1967 (4)	(\$1,000,000)				
Value Added	261,983.8	114,209.5	43.6	93,804.6	35.8
Capital expenditures	21,503.0	9,111.6	42.4	7,508.9	34.9
Employment	(1,000 employees)				
	19,323.2	7,858.2	40.7	6,473.2	33.5
Agriculture - 1969 (5)	(Value in \$1,000)				
All farm products sold	45,607,490	22,766,029	49.9	10,034,927	22.0
All crops sold	17,082,970	7,089,188	41.5	3,596,953	21.1
Livestock sold	18,973,188	11,725,262	61.8	3,451,596	18.2
Poultry and poultry products sold	4,002,241	752,392	18.8	515,030	12.9
Dairy products sold	5,549,091	2,802,193	50.5	2,222,484	40.1
	(Value in \$1,000)				
Retail Sales - 1967 (6)	310,214,393	114,629,621	36.9	83,082,764	26.8
Merchant Wholesalers Sales - 1967 (7)	459,475,967	167,699,282	36.5	123,731,255	26.9
Value of Mineral Production - 1969 (8)	26,927,827	7,050,045	26.2	3,223,023	12.0

(1) Excludes Alaska and Hawaii.

(2) The Great Lakes - Hinterland includes the eight Great Lakes border states of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, and western portions of Pennsylvania and New York and also the eleven additional adjacent states of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Kentucky, and West Virginia.

(3) U. S. Bureau of the Census, Census of Population: 1970, Number of Inhabitants, Selected State Reports, Final Report PC(1), U.S. Government Printing Office, Washington, D.C., 1971.

(4) U. S. Bureau of the Census, Census of Manufactures: 1967, General summary Subject report and selected Area reports MC67, U.S. Government Printing Office, Washington, D.C., 1970.

(5) U. S. Bureau of the Census, Census of Agriculture: 1969, Preliminary, U.S. Bureau of Census, 1972.

(6) U. S. Bureau of the Census, Census of Business: 1967, Retail Trade - Area Statistics, Volume II; U.S. Government Printing Office, Washington, D.C., 1970.

(7) U. S. Bureau of the Census, Census of Business: 1967, Wholesale Trade - Area Statistics, Volume III; U. S. Government Printing Office, Washington, D.C., 1971.

(8) U. S. Department of the Interior, Bureau of Mines: 1969, Minerals Yearbook, Volume III, Area Reports: Domestic; U. S. Government Printing Office, Washington, D.C., 1971.

25. PRIOR REPORTS

The reports under review are House Document No. 253, 70th Congress, 1st Session and House Document No. 423, 83rd Congress, 2nd Session.

House Document No. 253 was submitted to Congress on 30 April 1928 and recommended deepening the connecting channel between Lake Erie and the upper lakes and construction of compensating works in St. Clair and Niagara Rivers. The recommendations were authorized by Act of Congress approved 3 July 1930. Further deepening of the connecting channels was authorized on the basis of subsequent reports. The compensating works in Niagara River have not been constructed.

House Document No. 423 was submitted to Congress on 26 May 1954 and recommended minor modifications to Tonawanda Harbor. The recommendations were authorized by Act of Congress approved 3 September 1954.

A Feasibility Study for Review of Reports on Great Lakes and Connecting Waters With Reference to a Lake Erie-Lake Ontario Waterway, dated December 1961, was prepared in partial compliance with the above resolutions by Congress. The Feasibility Study concluded that a Lake Erie-Lake Ontario Waterway was physically and economically feasible and recommended that a more detailed study be made to confirm those conclusions.

Table 4 gives a historical listing of previous reports and investigations relative to an inter-lake waterway located in the United States.

TABLE 4
EXAMINATIONS AND REPORTS MADE ON ALL AMERICAN CANAL
BETWEEN
LAKE ERIE AND LAKE ONTARIO

Year	Description	Source	Construction	Cost \$	From	To	Recommendation
1784	First survey made for a canal around Niagara Falls by Niagara Canal Co.						
1798	State of N.Y. passed a law to construct a canal around Niagara Falls - never put into effect						
1808	Sec'y of Treasury submitted a report to U.S. Senate - a report on Niagara Ship Canal made by N.Y. State						
1826	Survey made by private interests						
1836	5 canal routes, L. Erie to L. Ontario, depth 10 ft; locks 20x50 ft.	H. Exec. Doc. 211, 24th Cong. 1st Sess	Canal with single locks Canal w/part single & part double locks	2,568,899 5,041,725	Schlossers Landing- Tonawanda	Lewiston Olcott	Favorable
1837	A study on the need for above	H. Doc. 201 24th Cong. 2nd Sess	" " " "	"			
1853	Several routes surveyed for a canal 11 ft deep, 130 ft wide, locks 300x70 ft.	N.Y. State appointed Chas. B. Stewart & Ed. W. Serrell	Canal with single locks Canal with double locks	10,290,172 13,169,570	Tonawanda Creek	L. Ontario	None
1863	The 1853 report modified to principal western harbor depths-canal 12' deep, 105' wide; locks 275x15'	Pres. Lincoln appointed Chas. Stewart	5 routes surveyed- single locks shortest 6.58 miles -double locks	6,007,001 7,680,555	Schlossers Landing	Lewiston	None
1864	Above report presented before Congress House Exec. Doc 61 w/special message from Pres. Lincoln	House Exec. Doc 61 38th Cong. 1st Sess					

* First Federal study made by Captain William G. Williams, 1st Buffalo District Engineer.

TABLE 4 (Cont'd.)

Year	Description	Source	Construction	Cost	From	To	Remarks
1868	6 canal routes-L.Erie to L.Ontario, depth 14 ft; locks 275x16 ft. Results of these surveys published in Chief of Engrs. Annual Rpt.	House Exec. Doc 197 40th Cong. 2nd Sess	With exception of Tonawanda-Olcott route all routes were for single locks. Tonawanda-Olcott contained 4 double locks and guard lock and dam on Niagara River	\$11,500,900 For 3 routes: 12,673,520 Schlossers Landing--Lewiston 13,993,636 2 mi. upstream from mouth Cayuga Cr.--Wilson 12,893,170 Tonawanda-Olcott	Schlossers Landing--Lewiston	Lewiston	None
1888	2 canal routes-L.Erie to L.Ontario, depth 21 ft; locks 400x80 ft.	1868 report revised on basis of 20' draft	Single locks Double locks Single locks	24,201,550 Wilson Route 29,347,900 " 23,617,900 Tonawanda-Olcott	Wilson Route " Tonawanda	Olcott	Favorable
1869	Presented a bill to Congress providing for a Commission to select one of the above routes and requested \$1,000,000 for construction. No action taken on bill.						
1892	Presentation of Niagara Canal by Rep. H. Rpt 1023 Bently before H. of Representatives	52nd Cong. 1st Sess	Same as 1888	Same as 1888	Same as 1888		Favorable
1896	Report of Rep. Chickering from Committee on Railways & Canals supporting H.R. 34 bill appropriating \$50,000 for survey	H. Rpt 423 54th Cong. 1st Sess	"	"	"		Favorable
1900	Part of Report covering Deep Waterway from Great Lakes to Tide Water 2 canal routes With regulating dam at head of L.Erie Without " " " " " " With " " " " " " Without " " " " " " With " " " " " " Without " " " " " " With " " " " " "	H. Doc. 1149 56 Cong. 2nd Sess	Canal 215' wide in earth & 20' in rock and 21' deep Canal 203' wide in earth & 250' in rock and 30' deep Canal 215' wide in earth & 240' in rock and 21' deep Canal 203' wide in earth & 250' in rock and 20' deep	42,393,203 43,214,344 73,435,350 75,084,453 48,453,753 49,274,891 75,572,250 77,221,343	LaSalle " " " Tonawanda " " "	Lewiston " " " Olcott " " "	Favorable " " " " " " "

TABLE 4 (Cont'd.)

Year	Description	Source	Construction	Cost	From	To	Disposition
1918	Canal 40 miles long, Bflo to Olcott	Dept. Commerce Rpt on Erie & Ontario Sanitary Canal Co. Sen. Doc. 301 65th Cong, 2nd Sess	Construct a 40 mile canal with 2 lift locks - one with lift of 208', the smaller 104'	125,000,000	Lackawanna	Olcott	Unfavorable
					Buffalo	via Tonawanda	
1920	Detailed study of 2 canals 215'-240' wide with 30' depths; locks 740' long, 80' wide	Portion of Warren Rpt written on Waterway between Gr. Lakes & Hudson River. House Doc. 890, 66th Cong. 3rd Sess.	Several routes considered - most feasible were Tonawanda-Olcott and LaSalle-Lewiston	77,221,353	Tonawanda	Olcott	This portion of report was favorable
				75,084,453	LaSalle	Lewiston	
1926	Report of Special Board of Engrs. on Waterway from G. Lakes to Hudson River	H. Doc. 7 69th Cong, 2nd Sess	Special board reviewed above report on basis of 30' canal	188,020,000	Tonawanda	Olcott	Unfavorable
				171,000,000	LaSalle	Lewiston	
1926	Preliminary examination & survey of waterway from Gr. Lakes to Hudson River	House Doc. 288 69th Cong. 1st Sess	Study considered routes on basis of 20' canal & 25' canal	110,000,000	Tonawanda	Olcott	Unfavorable
				125,000,000	LaSalle	Lewiston	

EXISTING CORPS OF ENGINEERS PROJECTS IN THE STUDY AREA

26. Introduction. The three existing Corps of Engineers navigation projects in the waterway area are described in the following paragraphs. No other Corps projects would be affected by the considered waterway.

27. Buffalo Harbor. The first improvement was authorized by the 1826 River and Harbor Act. The project has been progressively enlarged and modified by numerous subsequent acts, the most recent modification being in 1962. The existing project was completed in September 1962.

Plate 12 shows the location and detailed features of this project.

Buffalo Harbor was one of the areas included in the pilot program study for Great Lakes dredgines disposal. A slag dike enclosure was completed in October 1967 along the shore in the southern portion of outer harbor, adjacent to the dike-enclosed area that forms the existing small-boat harbor. Material from clamshell dredging in the Buffalo River and Ship Canal was mechanically transferred from scows into the enclosed diked disposal area in Fall 1967 and hydraulically transferred from scows into the diked area during subsequent years 1968, 1969, 1970, and 1971 when the area was filled to design capacity. Construction of diked disposal area No. 2 (Times Beach) was initiated in May 1971 and is now completed.

28. Black Rock Channel and Tonawanda Harbor. Plate 13 shows location and detailed features of the project that was authorized by the 1888, 1902, 1905, 1916, 1919, 1922, 1925, 1934, 1935, 1945, and 1954 River and Harbor Acts. The existing project is about 89 percent complete. The remaining work consists of improvement and extension of the guide

pier, which is considered to be inactive, and deepening of the lower 1,500 feet of the Tonawanda Inner Harbor, which is to be restudied. The total cost of the completed portion of the existing project to 30 June 1971 is \$10,457,093. Controlling depths are 21 feet in Black Rock Channel, 20 feet in Niagara River section of the channel and in the Tonawanda turning basin, 14 feet in Tonawanda Inner Harbor, and 12 feet in Tonawanda Creek channel.

29. Black Rock Ship Lock. The Black Rock Channel and Tonawanda Harbor Project provided for this lock, located at the foot of Bridge Street within the city limits of Buffalo. Refer to Plate 14 for complete location and details. The locks built in a natural side channel of the Niagara River between Squaw Island and the mainland, which has been completely incorporated within the project.

The lock has a length of 650 feet between miter sills. Available length for full width is 625 feet. Clear width between fenders is 68 feet. Depth on miter sills at low water is 21.6 feet. The nominal lift is 5 feet. The lock has an intermediate gate dividing the chamber into a 400-foot upstream length and a 250-foot downstream length. Filling and emptying time is 11 minutes. The lock is constructed of concrete walls founded on bedrock. Gates are miter type of steel construction and are cable operated by electric motors. The filling and emptying system consists of side culverts with side ports. Wing walls consist of stone-filled timber cribs with concrete caps. A lower guide wall, connecting with the lower west wing wall, has a length of 800 feet. It is also of timber crib construction with a concrete cap.

The lock, opened to traffic in 1913, is generally in poor condition. The concrete caps of the wing walls are deteriorating; operating machinery is obsolete. Some problems are being encountered with gate anchorages. The basic structure is still sound, and the lock probably can be kept operable for a number of years. However, some unpredictable outages can be anticipated, due to equipment breakdowns. Partial rehabilitation was performed in 1972 and 1973. One shutdown for repairs closed the lock for three weeks in 1973.

30. Niagara River. The existing project was authorized by the 1912 and 1930 River and Harbor Acts. Refer to Plate 15 for its location. This project provides for the dredging of the channel in Niagara River downstream of North Tonawanda.

CURRENT RELATED STUDIES

31. Introduction. A number of studies are underway on other areas of the Great Lakes-St. Lawrence Seaway System that may impact on Lake Erie-Lake Ontario traffic. The studies and their potential impacts are summarized in the paragraphs below.

32. Great Lakes and St. Lawrence Seaway Navigation Season Extension. Navigation on the Great Lakes and their connecting channels is suspended during the winter season from about mid-December to early April, because of the effects of ice. Commerce and industry served by navigation are forced to resort to stockpiling to carry them through the winter period or to use other modes of transportation. The survey study of the Great Lakes and Saint Lawrence Seaway,

Navigation Season Extension (authorized in Section 107(a) of the River and Harbor Act of 1970) is considering means of extending the navigation season on the Great Lakes and Saint Lawrence Seaway, including, but not limited to, determination of costs, economic justification, environmental effects, and degree of Federal participation. Any extension of the navigation season, facilitating traffic between Lake Erie and Lake Ontario, will have an impact on the locks and channels of the Welland Canal. Season extension could reduce congestion at the existing Welland Canal if the volume of traffic moving over the normal 8-1/2 month season was spread out over the longer 9-, 10-, 11-, or 12-month extended season. However, if navigation season extension significantly changes the production and consumption patterns of industry in the Great Lakes region, total waterborne commerce on the Great Lakes-Saint Lawrence Seaway System could represent a net increase in total season traffic, which would have a reverse effect and add to congestion of the waterway system. Season extension would also require ice management and present maintenance scheduling problems, which could tax the administrative and physical limits of the existing Welland Canal and for which an alternate canal would provide additional flexibility. The study is scheduled for completion in FY 1979.

33. Saint Lawrence Seaway, Additional Locks. The Saint Lawrence Seaway connecting the Great Lakes with the oceans of the world via the Saint Lawrence River opened to navigation in 1959. Since that time, traffic on the Seaway has grown from 20.3 million tons in 1960

to over 53.0 million tons in 1972. The dimensions of the locks are 800' by 80'. Current experience and projected traffic volume indicate that the practical capacity of the Saint Lawrence Seaway locks will be reached about the same decade in which the existing Welland Canal capacity is exhausted. Concurrent studies are underway to determine the engineering and economic feasibility of providing additional locks on the Saint Lawrence Seaway. Since only the two upper locks in the Saint Lawrence System are operated by the United States, coordination with Canada will be necessary to complete any addition of locks throughout the system. The current survey study will be completed in FY 1977.

34. Great Lakes Connecting Channels. The Great Lakes Connecting Channels include the waterways between Lakes Superior-Huron, Huron-Michigan, and Huron-Erie. Existing projects provide channels varying in depths from 27 to 30 feet and widths from 300 to 1,500 feet in Lake Superior, St. Marys River, Straits of Mackinac, Lake Huron, St. Clair River, Lake St. Clair, Detroit River, and Lake Erie. Waterborne commerce using the system exceeds 100,000,000 tons and is comprised primarily of the bulk commodities of iron ore, coal, stone, sand and gravel, grain, and petroleum products. The system is linked to overseas trade by the Welland Canal, Lake Ontario, and the St. Lawrence Seaway. The New Poe Lock at Sault Ste. Marie has dimensions of 1,200 feet long by 110 feet wide by 32 feet depth over the sills. The opening of this lock has led to construction

of two new self-unloading supercarriers, both of 105-foot beam; one 1,000 feet long and one 850 feet long, and both capable of drawing 31 to 32 feet of water. These supercarriers became operational during the 1972 shipping season. Other lake carriers are being lengthened to 806 feet. One 806-foot lake carrier was operating during the 1972 season, and another is scheduled for launching in the spring of 1973. The economies available with larger vessels, and possibly an extended operating season, lead toward construction of more of these large vessels. They will not be able to operate at full draft and optimum safety in the existing channels, harbors, and facilities. The current study will investigate the engineering and economic feasibility of widening and deepening connecting channels in the Great Lakes. The major implication of this study as related to the canal between Lake Erie and Lake Ontario is the impact on trends toward larger vessels and the increased demand for navigation locks to accommodate sizes greater than 730 feet x 75 feet, the present maximum capacity of both Welland and St. Lawrence Seaway facilities. The study will be completed in FY 1980.

35. Great Lakes Harbors Studies. Present study authorizations exist at Duluth-Superior Harbors, Minnesota and Wisconsin and Cleveland Harbor, Ohio. Deepening and widening of harbor approaches and channels are under study, thus presenting an additional indication of the demand for accommodating larger vessels in the Great Lakes

St. Lawrence Seaway System. Both studies are scheduled for completion in FY 1976.

SCOPE OF STUDY AND PLAN FORMULATION

36. Introduction. During construction of the St. Lawrence Seaway, concern developed in the United States that the Welland Canal in Canada would restrict anticipated increased commerce in the Great Lakes Basin area that would otherwise be developed through use of the new seaways. With this in mind, Congress authorized studies relative to the development of a plan for a Lake Erie-Lake Ontario Waterway, as an integral part of the Great Lakes-St. Lawrence Waterway System, to meet the growing needs of the Great Lakes Basin area for modern up-to-date waterborne transportation facilities. The objective of these studies is to aid the regional and national economies.

In addition to this basic objective, the considered plan should benefit the immediate Buffalo-Niagara County area by providing modern efficient waterborne transportation facilities that would encourage the overall economic and recreation development of the area. The plan must be technically feasible and socially acceptable to local interests and must give full consideration to preserving, or enhancing where possible, the quality of the local environment.

The formulation of any plan for the waterway must also give due consideration to the needs and objectives of Canada with

respect to the future development and operation of the existing Welland Canal.

37. Consideration of the Needs. Waterborne commerce between Lake Erie and Lake Ontario has been increasing steadily in recent years. A continuation of this growth would result in traffic reaching the capacity of the canal. Traffic in excess of this amount would be forced to seek other routes, probably higher-cost ones, creating an adverse impact upon the economy of the region. In order to permit continued growth of the region, this report has considered development of a waterway in United States territory to provide the additional traffic capacity needed for future demands. The objective was to develop a waterway to permit safe and convenient passage between the two lakes for modern vessels using or expected to use the Great Lakes-St. Lawrence Waterway System.

Terminals for waterborne commerce along the Niagara River between Buffalo and North Tonawanda are not served by modern navigation channels. A modern interlake waterway would meet the navigation needs of these terminals.

Various groups in the immediate project area have expressed interest in development of harbor facilities on Lake Ontario in Niagara County. The considered project could provide the basic harbor for development of dock facilities by local interests.

The immediate project area is short of recreational space, even on the basis of only resident demand. Superimposed upon this

demand is a heavy nonresident demand resulting from tourist attraction to the Niagara Falls area. The project lands and waters could make some contribution to meeting the demand for recreational space.

38. Special Problems. Waterpower - Use of Niagara River water will reduce the amount of water available for generation of hydroelectric power. There will be some economic loss. It might be possible to develop ways of reducing demand for water for canal service during daylight hour; however, this would be a complex matter and is considered beyond the scope of this study.

Water quality - The Niagara River is used for municipal and industrial water supply and for recreational purposes. The considered waterway plan will be developed to minimize adverse effects. Improvement of the quality, however, is not an objective of the plan.

Environmental - In addition to the physical and ecological environment, the studies were concerned with the waterway's effect upon the social, recreational, and cultural environment.

39. Objectives of Investigation. The objective of this investigation was to determine a feasible plan of improvement and then submit a report to Congress containing information on costs, benefits, regional and environmental impacts, and effect upon the well-being of the population. The purpose was to furnish a basis for the decision of Congress regarding any further action on a new inter-lake waterway. The study recognizes the relation between the plan

and various planning objectives and discusses problems and the relation of the plan to Canadian activities on the Welland and St. Lawrence Canals. The report makes recommendations regarding a further effort, but no recommendation regarding construction.

The study considered four basic objectives and the relative extent of treatment of each objective is discussed below:

a. National economic development - This objective was treated in considerable detail, since it is the area where a major waterway improvement would have significant impact. The only benefits used in the economic justification of the proposed improvement were the transportation savings to the system.

b. Environmental quality - The proposed improvement was studied to determine what the environmental impact would be, what mitigation measures could be added to the basic plan, and what measures could be taken to improve the quality of the environment, without significantly changing the scope of the basic plan. Assessment of the environmental impacts can be found in Appendix E.

c. Social well-being - No plan was developed specifically to meet this objective; however, many of the components of the objective were considered and discussed. The economic implications of the proposed improvement would have a system effect. The basic plan appears to contain potential first, to aid population dispersal by encouraging development of the mid-continent, by adding import-export capability to this area in lieu of further expansion of crowded

East Coast ports; second, to improve conditions contributory to attainment of economic stability, by adding needed capacity to the Great Lakes water transport system; third, to enhance recreational opportunities by development of project lands and waters for recreational use; and fourth, to improve the traffic potential of both Canada and the United States, by providing reserve capacity for Great Lakes water transport.

d. Regional development - A project of this magnitude is quite likely to have an effect on regional development. The environmental study developed information specifically related to regional development. The basic plan appears to offer opportunities for environmental enhancement and contributions to the social well-being of the region.

This review of reports was limited to consideration of studies needed to make as complete an analysis of waterway improvements as could be made with time and money constraints. There was no project formulation in the usual sense, on the basis of the four objectives currently used for water resource planning. The report presents a plan that is technically feasible, but not necessarily the most desirable from the standpoint of multi-objective planning. Only one basic plan was considered, a scheme involving five locks on a waterway alignment shown on Plate 1. This alignment was studied in more detail than other possible alignments. Other lock schemes for this alignment were also studied and the five-lock scheme was selected as the most desirable plan from a technical standpoint.

The selection was made on the basis of judgment by experienced personnel, not on the basis of detailed comparisons of cost or other factors. The scope of further studies was controlled to a considerable degree by work done previously.

Detailed studies were made in a number of areas. Designs and cost estimates, detailed in Appendix A, analyzed lock and canal design and developed costs for their construction. Geologic information on the canal route, detailed in Appendix B, Geology, Soil, and Materials, provided data on the amount of rock and overburden to be removed and the ability of the rock foundations to support a canal and locks. The investigations into hydrology and hydraulic design, reported in Appendix C, provided methods for efficient filling and emptying of locks. Waterborne commerce projections, the estimated year in which an improvement would be needed, and economic analysis of the benefits and costs were made in the economic study, Assessment of the impacts of the project on the ecological and social environment, including recreational and cultural benefits and losses, had to be presented, and are detailed in Appendix E. In addition, input from the public was obtained on their needs and desires relative to the project.

EXTENT OF INVESTIGATIONS

40. Designs and Estimates. Designs and estimates, in general, were made in detail appropriate for a report of survey scope. However, the lock structural design was carried out in considerable

detail. The combination of lift, width, length, and depth over sill called for locks of unprecedented size, which created some doubt as to whether such locks could be built. Therefore, the structural design was done in sufficient detail to establish that the locks could be built using acceptable design criteria. Detailed design of a typical section of the retention dikes established that unusual problems would not be encountered. For other structures, designs were carried out in appropriate detail for survey scope estimating purposes. It was concluded that the canal is engineeringly feasible.

a. Canal alignment. Six alternate overland routes were studied in some detail. Four of these routes were eliminated by the early studies. The remaining two routes, designated A-1 (the proposed alignment) and C-2 were studied in further detail. These alignments are shown on Plates B-2 through B-5 in Geology, Soil, and Materials, Appendix B. The proposed alignment is shown on Plate 1. These two routes have a common alignment from Buffalo Harbor to a point on the overland route, about 3 miles north of the Niagara River. The two alignments separate here with the C-2 alignment crossing the escarpment about 2-1/2 miles east of the other. More effort was devoted to the A-1 alignment. This was because: (1) it is about one mile shorter than the C-2 alignment, (2) probing data indicate a top or rock profile may be more adaptable to lock locations, (3) the first lock located at the escarpment appears to afford a better opportunity for providing necessary surge basins, and (4) relocations

along A-1 appear to be less complicated and less expensive. Basic criteria used for canal alignment studies are as follows:

- (1) Canal depth will be 30 feet, minimum, and
- (2) Canal width will be 500 feet with provisions for future widening to 700 feet, in the overland rock cut area, 700 feet in areas between locks below the escarpment and in the Niagara River downstream of the new Black Rock Lock, and 600 feet in the Black Rock Canal upstream of the new lock. The only exception to the widths will be a short stretch for initial construction in the vicinity of the Buffalo sewage disposal plant and at the Grand Island Bridges. Widths in these areas will be 400 feet.

b. Lock locations and layout. Lock layouts were made for both the A-1 and C-2 alignments. These involve one lock at Black Rock and 4- and 5-lock combinations from the escarpment to Lake Ontario. These are referred to as the 5-lock and 6-lock plans, respectively. For the former, the four high-lift locks would each have 80-foot nominal lifts. The latter would include five high-lift locks with 64-foot nominal lifts. The Black Rock lock would have a nominal lift of 5 feet. The basic criteria used for lock layouts are as follows:

- (1) Locks will be 110 feet wide, with 1,200 feet center-to-center of operating mitergate pintles. A possible intermediate gate has been considered to handle vessels up to 730 feet. These would predominate in early years of the canal. An intermediate

gate would reduce lockage water and thus loss at hydro-electric plants.

(2) Lock centerline will be offset from the center line of canal by 295 feet to allow for possible future parallel locks.

(3) Each lock will have four sets of mitergates; one upper gate; two lower gates; and a spare upper gate at the lower end for unwatering. This is the same arrangement used for the new Poe Lock.

(4) Closure at the upper ends of locks will be by stop logs. Additionally, the first lock north of the Niagara River will be provided with a vertical lift gate at the upper end in addition to the mitergate and stop logs.

(5) Three wire rope fenders will be provided at each lock to protect mitergates.

(6) Filling and emptying of locks except for the new Black Rock Lock will be through surge basins separated from the main canal by dikes.

(7) Conventional reverse tainter gates will be used for all valves.

(8) Both conventional transverse and longitudinal bottom lateral filling and emptying systems will be considered for all the high lift locks.

(9) Thirty-five foot minimum depth will be maintained over all lock sills.

(10) Two thousand foot long, upper and lower guide walls will be provided at each lock.

c. Relocations. Layouts were made for six-lock plan and canal alignment combinations for all relocations involving utilities (water, sewer and gas), railroads (except the International railroad bridge across the Black Rock section of canal) and highway work. Criteria used for relocations are as follows:

(1) One-hundred-twenty-foot minimum vertical overhead clearance at all new bridges.

(2) Seven-hundred-foot minimum horizontal clearance at all new bridges.

(3) No local narrowing of the waterway will be considered if solely for reasons of economy. The two exceptions to this rule are the two Grand Island bridges, which we are assuming will be raised, and the section near the Buffalo sewage disposal plant discussed previously.

(4) Maximum railroad curve will be 1.5 degrees.

(5) Maximum railroad grade will be one percent.

(6) Maximum highway grade will be four percent.

(7) No movable bridges will be considered on the overland reach.

(8) Relocation or partial abandonment of highway will be determined by comparing relocation costs with the user expenses for each facility if the relocation were not constructed.

d. Preliminary design. Basically, preliminary structural and mechanical design was done on both the lock components and relocations as necessary to: (1) support cost estimates; and (2) with respect to some of the unprecedented-size lock components to insure that a reasonable result can be obtained. The preliminary design for the 5-lock plan on alignment A-1 is complete. All preliminary design has been based on criteria (1965) as presented by the various engineering manuals.

e. Property requirements. Layouts have been completed detailing real estate requirements for all considered combinations of canal alignment and lock locations.

f. Cost estimates. Detailed cost estimates have been prepared for one plan, the 5-lock scheme shown on Plate 1. No cost estimates have been prepared for the other possible routes.

An extensive field survey program was required to obtain data for design and estimating purposes. Much topographic data along the overland section were available from the State Department of Transportation. Lake Ontario soundings were available from the U. S. Lake Survey Center. Soundings and probings for ledge rock were taken in the Niagara River between Squaw Island and the junction with the overland section. Cross-sections were taken of the Bird Island pier over the length considered for relocation. Soundings and probings were available in the project areas of Black Rock Canal and of Buffalo Harbor. The Buffalo Harbor-North Entrance Channel

was swept to locate obstructions above 30-foot depth. Data were obtained from highway agencies on traffic on highways affected by the project. Information was assembled on all structures and utilities on or crossing the considered route.

Further information on designs and estimates is given in Appendix A.

41. Geology, Soils, and Foundation Investigations. An extensive subsurface investigation program was conducted as part of the study, primarily in the overland section. Numerous core borings were taken in order to locate top of rock and obtain samples for testing of both overburden and underlying rock, necessary to determine the quantity of rock to be excavated. The examination of rock cores at or near lock sites, cyclic loading tests of rock samples and other laboratory testing, and analysis of samples provided a basis for design of locks and dikes. Additional effort was oriented primarily toward finalization of design of canal dikes, utilization of excavated material, and designs of breakwaters for Lake Ontario harbor. Based on the studies and analyses performed, it was concluded that construction of the proposed waterway is feasible insofar as local soils and geologic conditions are concerned. Further information on these investigations is contained in Appendix B.

42. Hydraulics and Hydrology. Hydraulic studies were concerned with the effect on the flow of the Niagara River and on hydraulic problems with filling and emptying the locks. Model studies were

made of possible lock arrangements at Squaw Island. These determined the effect on river flow and the distribution of flow between East and West Branches. The model study then determined the nature and extent of remedial work needed to maintain flows in their present condition. Another model study was made of the junction of the river channel with the overland canal section. The study developed a plan free from objectionable cross-currents in the river on the approach to the canal.

The relatively large, high locks being considered can create surge problems in the canal, when filled or emptied. Plans have been developed for surge basins parallel to the canal. The locks will be filled from and emptied into the basins. The water will then be allowed to flow to and from the canal. These flows will be distributed over a considerable distance and eliminate the surge problem. This would prevent serious surges that would create hazardous navigation conditions for vessels using the canal. The hydraulic studies have also covered very preliminary design of filling and emptying systems for the locks.

Hydraulic studies have concluded that the canal is hydraulically feasible with the inclusion of the surge basins. Further information on investigations for hydraulic and hydrologic problems is contained in Appendix C.

43. Economic Studies. The Economic Studies called for a complete in-depth analysis of the benefits associated with a plan, providing an alternative to the existing Welland Canal. That alternative

is a 5-lock canal in the Niagara River and then overland to connect Lake Erie with Lake Ontario and the St. Lawrence River. Each of the 5 locks are sized at 1200' x 110' with a 35 foot depth over lock sills.

Considerable pertinent data to the economic study were available from other recent studies. In addition, a number of investigations were made for this study. The origin-destination study was made of all waterborne movements utilizing the Welland Canal in 1970. A transportation rate study was made for waterborne and overland alternative routings for commodities moving or projected to move through the Great Lakes-St. Lawrence River System. Also, a computer simulation analysis of the existing Welland Canal was done in order to determine when the traffic passing through the Welland Canal would be constrained by the physical capacity of the system. The traffic and simulation studies indicated that without major structural improvements, the Welland Canal will reach practical capacity by 1990 under conditions represented by projected traffic and optimum traffic management. Appendix D contains details of the Economic Studies.

44. Impact Assessment and Environmental Plan. This area of study covered not only the environmental impact, but also looked for ways to improve the quality of the environment within the scope of the one considered plan.

The environmental study first inventoried the existing environment. It then assessed the impact of the basic plan.

Next, modifications were made to avoid adverse impacts and to produce desirable impacts. Mitigation measures were recommended where adverse impacts cannot be avoided without undue changes in the consideration of the project. The study considered all elements of the environment including geologic, hydrologic, botanic, zoologic, archeology, prehistoric, cultural, economic and social, and any other of influence elements found to be significant during the study. An environmental impact statement was prepared, since the report does not make a recommendation for construction.

The Environmental Study depends for the most part on available data supplemented by field inspections and interviews with local officials and local agency residents. The most significant impacts appear to be the loss of homes due to the acquisition of homes and the loss of the surrounding. Some of the adverse impacts can be minimized. Others, although unable to be mitigated, have minimal impacts that our environmental consultant has evaluated as acceptable considering the magnitude of the considered canal. The complete environmental assessment is contained in Appendix E.

45. Public Involvement. Civic, commercial, and political interests in the Buffalo-Niagara Falls, New York, area were the early proponents of a study of a canal in United States territory between Lake Erie and Lake Ontario. About the time the deepdraft St. Lawrence Seaway was nearing completion, these groups became concerned that the

Welland Canal in Canada would become a bottleneck, restricting the anticipated increased commerce that would otherwise use the new Seaway. Therefore, these groups were instrumental in obtaining authorization for the study.

The New York State Joint Legislative Committee on Commerce and Economic Development held a public hearing on the considered waterway on 5 October 1960. It was attended by about 50 persons representing business, commerce, labor, shipping, and government. Statements presented were generally in favor of improvement, with rather general discussions of future commerce, ship traffic, and potential problems with the Welland Canal. Another public meeting was held by the State Joint Legislative Committee on Navigable Waterways at Buffalo on 6 December 1965. It generally repeated the preceding hearing.

In addition, the Corps of Engineers has had informal meetings and five public information meetings with various groups and local residents of the area along the route. These were generally to inform the groups of the nature of the plan. As might be expected, local business and commercial groups generally favor the improvement. Officials of communities along the route are concerned about loss of tax base, disruption of community services, and impact on demand for government services. Area residents are concerned about loss of homes and property and disruption of community patterns. Final public meetings were held, one in Niagara County to obtain final comment from local citizens, and the other in

Chicago, Illinois, to allow interests from the larger affected area to give their opinions. The section preceding Conclusions near the end of this Main Report details these final meetings. Throughout the study, many feature articles have appeared in area and Great Lakes region newspapers.

ECONOMIC ANALYSIS

46. Introduction. The economic studies of the need and justification for a canal in the United States as an alternative to the existing Welland Canal utilized two major research efforts. These were (1) an origin-destination study of existing and projected traffic with estimates of future fleet size and composition and transportation rates forming the basis for projections of future volume and of traffic patterns and (2) a computer simulation model of the Great Lakes Navigation System to determine traffic capacity and design parameters of timing, sizing, and sequencing of alternative navigation improvements. The simulation model combines data and projections from the origin-destination study together with actual Welland Canal operating procedures (which in terms of scheduling and traffic control are to a large degree already optimized) to examine the capacity level of the existing Welland facilities. The alternative Niagara Canal was simulated using design specifications for system operations together with observed data of the Poe Lock at Sault Ste. Marie, Michigan, which is the only 1200' x 110' lock facility currently operating in the Great Lakes-St. Lawrence Seaway System.

Projections of United States and Canadian domestic and foreign traffic were developed for 1980, 1990, 2015, and 2040 utilizing a base year of 1971. Simulation analysis was conducted on a decadal basis

from 1980 through 2030, again using a base year of 1971. Benefits are quantified for transportation savings as well as secondary effects resulting from the project. Detailed reports on Traffic Studies, Transportation Rate Differential, and Simulation are contained in Appendix D.

47. Basic Assumptions. The following assumptions were used in the analysis of economic development and traffic potential for the Great Lakes-St. Lawrence Seaway System.

a. There will be no major wars between nuclear powers, no national economic depressions, no world-wide economic depressions or international trade wars, and no failure of the international monetary structure will constrain projected volumes of commodity movements.

b. All other factors being equal, commodities will move from origin to destination by the most economical route.

48. Sources of Data. Tonnage statistics of import and export commodities at each Great Lakes harbor, as well as at every United States ocean harbor, were available from the annual reports of U.S. Waterborne Commerce published by the U.S. Army Corps of Engineers and are based on foreign trade data compiled by the Bureau of the Census of the U.S. Department of Commerce. Also, detailed data were available for commodity imports and exports for the United States as a total and for various Customs Districts. However, no data were available in any complete and collected form for routings from actual points of origin of an export to the ports of exit, thence by water transport to the foreign port. Likewise, no import data were available from the overseas ports of shipment to U.S. ports of unloading

and thence to interior points of ultimate destination in the United States. A survey entitled "Domestic and International Transportation of U.S. Foreign Trade: 1970"^{1/} was sponsored jointly by the Department of Transportation and the Department of the Army, Corps of Engineers and was undertaken by the Bureau of the Census to include "liner-type" commodities moving internationally by vessel or air.

This survey was undertaken primarily to obtain new data on the domestic leg of U.S. foreign trade and to link those new facts with already available information on the international segment of "liner-type" commodity flows. The new data alone shed substantial light into a very dark statistical area--the origins, destinations, means of transport, and distances involved in foreign trade movements within this country. The coupling of the domestic and the international legs of each shipment in the sample creates a new set of data for use in the systematic analysis of commodity flows between the interior of the United States and foreign countries.

This survey replaced and updated a smaller, but similar survey of waterborne exports and imports during 1956. That study, entitled "Domestic Movement of Selected Commodities in United States Waterborne Foreign Trade: 1956," was sponsored jointly by the Corps of Engineers and Traffic Executive Associates, Eastern Railroads, and was also undertaken by the Bureau of the Census. The U.S. Department of Commerce completed a survey of the origin of the exports of manufactured products for 1960 and 1963. These data were used to supplement the information

^{1/}U.S. Bureau of the Census, Domestic and International Transportation of U.S. Foreign Trade: 1970, U.S. Government Printing Office, Washington, DC 1972.

obtained from the special Origin-Destination Study discussed previously. Also, no data were available in any complete form for routings from actual points of origin of a bulk shipment to the ports of exit, thence by water transport to the domestic or foreign receiving port. Likewise, no data were available on receipts from the domestic or overseas ports of shipment to domestic and U.S. ports of unloading and thence to interior points of ultimate destination. To overcome this lack of data, a cooperative agreement for a study of bulk commodity movements in the Upper Great Lakes Region was entered into by the North Central Division with the Upper Great Lakes Regional Commission.

The origin-destination study of bulk commodities was an inter-agency Federal and state effort. The Bureau of Mines, U.S. Department of Interior, furnished data on existing and projected production, markets, and transportation of mineral commodities in the Upper Great Lakes Region as well as identifying environmental and technological restraints. Also the Economic Research Service and the Forest Service, U.S. Department of Agriculture, have furnished production and shipment data on grain and forest products, respectively. The Corps of Engineers Waterborne Commerce Statistics Center in New Orleans provided a special study of the origin-destination of domestic and foreign bulk commodity movements for the shipping and receiving harbors in the Upper Great Lakes Region. This information was used for analytical purposes and aggregated into lake areas to avoid disclosure of individual operations. In addition to the traffic data supplied by the Waterborne

Commerce Center, were the reports of the St. Lawrence Seaway Development Corporation (United States) and the St. Lawrence Seaway Authority (Canada). These annual reports entitled Traffic Report of the Saint Lawrence Seaway provided data on commodity and direction of Canadian traffic, as well as serving as an additional source of data for United States Great Lakes and St. Lawrence Seaway movements.

49. Base Conditions. The existing Welland Canal is a man-made channel providing for deep-draft navigation around Niagara Falls. At present, nearly 65 million tons of commerce moves annually through the Welland Canal in ships of virtually every flag in the international merchant marine fleet. Since each of the locks has a physical dimension of 800 feet in length and 80 feet in width, vessel sizes range from the smallest packet boat of 200-400 feet in length to bulk carriers in the 700-730 foot class. Draft limitations are controlled by the Great Lakes-St. Lawrence Seaway System depth of 27-feet.

United States waterborne commerce on the Great Lakes in 1971 totalled 208 million tons. Of that total, 44 million tons utilized the Welland Canal. In addition to the United States traffic through the Welland Canal, nearly 19 million tons of Canadian domestic and overseas commerce raised the total tonnage of the Welland to 63 million tons. Table 5 summarizes the traffic at the existing Welland for recent years and points out the heavy utilization of the Canal in U.S.-Canada and Canada-U.S. traffic interchange. Of the 44 million tons of U.S. traffic through the Welland Canal in 1971, 27.5 million tons involved waterborne trade between U.S. ports west of the Welland and the Canadian ports to the east.

The 27-foot deep Welland Canal has been in operation since 1932 and, together with the 27-foot St. Lawrence Seaway projects completed in 1958, provides a deep-draft waterway between the Great Lakes and other world ports. The completion of the Seaway forced the Welland into double duty. That is, in addition to a substantial volume of interlake traffic, a new increment of ocean going commerce was added. As a result in the early sixties, the Welland Canal faced the conundrum of older locks (in comparison with the Seaway) and channels, coupled with a substantial lift, and faced with a period of accelerated growth in Seaway traffic. In 1964, a round trip Welland passage averaged between 50-60 hours in some months. To reduce transit times through the 28-mile canal, a traffic management system was installed including computer analyses of operations, closed circuit television monitoring, and radar control. In 1965 the same round trip passage that took 50-60 hours a year earlier was reduced as much as 20 hours. From near maximum capacity, the Welland was estimated to have 22 percent spare capacity after the completion of the traffic management system.

Another major improvement at the Welland, completed only recently in 1972, is a bypass canal, which has further reduced transit time through a more efficient alignment of the canal. At present, total round-trip transit time in the Welland Canal averages between 25 and 30 hours.

Waterborne traffic is continuing to grow on the Great Lakes-St. Lawrence Seaway System, and 1972 was a record year at the Welland Canal with the passage of over 64 million tons. A continuing concern

of United States and Canadian interests is the practical capacity of the Welland and the timing for provision of added improvements and capacity to meet the increasing traffic demand. The study of the Lake Erie-Lake Ontario Waterway was authorized by Congress to address this question and to determine the feasibility of an alternate canal in the United States in the vicinity of Buffalo, New York, by way of the Niagara River.

50. Methodology. Three elements of study were closely interwoven to form the methodology for addressing the following questions: Potential waterborne commerce between Lake Erie and Lake Ontario in future decades; advantage of waterborne commerce over alternative modes, reflected in net transport rates for moving goods from origin to destination; and given traffic volume and vessel characteristics, the theoretical capacity of the existing system, i.e., Welland Canal.

The fourth step in the program is facilitated once the above three quantification processes have been completed. That is, the economic feasibility of various alternative improvement plans may be tested by equating costs of improvements with system transportation savings. Each of these four steps is summarized below. In addition, Appendix D addresses in detail the subjects of traffic, transport rates, and simulated capacity studies, respectively.

a. Traffic. The data base in these studies was provided in published and special commodity data reports available through the St. Lawrence

Seaway Authority, the St. Lawrence Seaway Development Corporation, and the U.S. Army Corps of Engineers, Waterborne Commerce Center. The data included historical traffic movements by detailed three-digit SIC commodities, type (overseas, domestic, internal, coastwise, etc.) and direction of movement, and port of origin and destination. These data grouped into origin-destination (O/D) traffic matrices provided the basic tool for the projection of future traffic.

Each cell of the O/D matrix revealed not only a waterborne port of origin and destination, but also shed important light on inland supply areas servicing Great Lakes ports for shipment and utilizing Great Lakes ports in receipt of waterborne commodities. In addition, for the large number of general cargo commodities, an origin-destination study of inland points of production and consumption^{2/} was conducted by the U.S. Bureau of Census under contract with the U.S. Army Corps of Engineers and Department of Transportation.

Supply and demand analyses were made for each of the five major bulk commodity groups of grain; coal; petroleum; clay, cement, stone, sand, and gravel; and iron ore. Published data on production, consumption, and export-import requirements were consulted as available from the U.S. Department of Agriculture, U.S. Bureau of Mines, U.S. Army Corps of Engineers, and various Canadian sources (for reference to specific studies consult bibliographies in Appendix D). In general, marketing areas were developed for each of the seven commodity groups. These seven groups include the five groups listed above, plus general

^{2/}

Ibid.

cargo, and other bulk commodities. A 19-state Great Lakes tributary area was delineated extending from Wyoming in the west to Missouri in the south and West Virginia at the easternmost boundary.

Alternate sources of supply were considered, including production cost and transportation rate differentials among traffic modes. Technological, environmental, and governmental policy positions were investigated in relation to each commodity, particularly grain, coal, petroleum, and iron ore. Container advantages were assessed including the competitive position of the Great Lakes ports under present and potential conditions. As a rule, where policy or production/consumption practices are clearly in a state of transition, a conservative outlook with reference to future waterborne traffic potential was adopted. Finally, many excellent published studies were consulted for additional background on local, national, and international events that are likely to impact on future waterborne commerce via Great Lakes ports and the Lake Erie-Lake Ontario Waterway. Traffic projections for each of seven commodity groups were developed for periods 1980, 1990, 2015, and 2040.

b. Transportation Rate Analysis. As part of the overall Lake Erie-Lake Ontario Study, the research efforts centering upon comparative freight rates has the purpose of providing substantive data to assist in development of the overall benefit/cost ratio. A thorough study of the relative rates for selected commodity movements has been undertaken leading to the identification of the routings with the

least alternative costs. Refer to Appendix D for a full discussion of the methodology and findings of the Transportation Rate Analysis.

In September 1972, the Bureau of Census published the study Domestic and International Transportation of U.S. Foreign Trade: 1970. These origin-destination data on liner type general cargo serve as a basis for addressing transportation costs for waterborne and competing overland transport modes. Net differential in transportation costs are correlated with prevailing transportation rates to provide the basis for determination of unit transportation savings and benefits in accordance with Section 7(a) Transportation Act (PL 89-670), 1966. First, a representative list of commodities produced or consumed in the Great Lakes Area and entering the trade stream overseas was selected.

The Bureau of Census origin-destination computer tapes were then analyzed for the following information on the selected 41 commodities: Production Area or Market Area of origin and destination (PA&MA's are groups of closely related SMSA's); the state of origin or destination; Customs District and port of entry or exit; overseas trading area of ports; and data on containerization susceptibility.

Closely related to selection of the origin-destination sites was the selection of appropriate ports of entry or exit. In every case, at least one Great Lakes port was included for every commodity, but the coastal ports varied with the characteristics of the commodity movement under consideration. For each commodity, the appropriate Great Lakes port or ports were selected with the choice of the coastal ports being contingent upon the overseas area to be served. A range of overseas ports

generally served as the origin or destination for the rates used in this study.

The basic rates for the overland portion of the movement, both rail and truck, were provided by Eastern Area Military Traffic Management and Terminal Service, Brooklyn, New York. They consisted of the lowest applicable January 1973 rate, either commodity or class, from the published tariffs. The deep water rates applicable during Autumn 1972 were obtained from individual water carriers or their agents to the extent possible. For water rates that could not be obtained from individual firms, the Federal Maritime Commission in Washington, DC, provided information from their public files. A figure for the "open" or "negotiated" rates on grains was developed by taking the average of the "tramp rates" for port-to-port movements for a 4-month period (September through December) as published in Maritime Research Incorporated, Chartering Annual, 1972 .

All water rates, whether weight or measure, were reduced to a hundred-weight basis. Measurement cargo was converted to a hundred-weight basis through use of one stowage factor for each commodity. Wharfage charges were only considered applicable when directly paid by the shipper. These charges are stated in the port handbooks and tariff sheets, and in this study, the appropriate figure has been added to the total rate. The final component that has been included in the overall rate for each commodity is the charge for the Seaway tolls.

The data were then analyzed to determine which port held an existing advantage in the movement of an individual commodity to or from domestic, Canadian, and overseas areas. The freight rate advantage of commodities actually moving from Great Lakes ports was weighted on the basis of interior points of origin or destination and overseas world area and port. In this way a value for a freight rate advantage was expressed for each commodity movement through the Welland Canal.

The least cost alternative from any point of origin or destination would be the inland modal and port of entry or exit with the smallest total dollar figure. A cheap ocean rate could be more than offset by a high rail rate because of a long haul to the port of entry or exit. The totals shown include land rates, ocean rates, seaway tolls, and port terminal and wharfage charges.

Detailed rates from origin/destination points through alternative Great Lakes or Coastal ports to overseas trading areas are shown in a separate document "Intermodal Domestic and Overseas Waterborne Rate Analysis for Great Lakes Area Commerce", for this study. These summary rate sheets include the forty-one commodities considered representative of the traffic shipped through the Welland Canal for domestic, Canadian, and overseas markets. First the bulk commodities including grains, coal, petroleum products, and iron ore, and secondly general cargo including food and kindred products, chemicals, iron and steel products, machinery, transportation equipment, and other manufacturing are discussed.

c. Simulation of Lake Erie-Lake Ontario Waterway. A simulation model was developed and applied to examine the performance of the existing Welland Canal under future traffic levels to determine the effect on transit times and adequacy in terms of future capacity. The objective of the simulation study was to establish the limits of service in terms of delay and transit times. Waterborne transport demand through the year 2030 was considered in the analysis, demand being represented by two factors, traffic density and fleet composition. The results of the study were portrayed as a series of transit time response curves for each alternative, plotted as a function of the transport demand. A description of the simulation process and the results are discussed in Appendix D and will be further treated in a consultant's report published under separate cover by the Traffic and Transportation Safety Center of the Pennsylvania State University, the contractor for the simulation phase of Lake Erie-Lake Ontario Waterway Study.

d. Economic Feasibility. In response to the resolutions of Congress, the main charge of this study is to determine the need and justification of a United States alternative for navigation between Lake Erie and Lake Ontario. Such feasibility must take into consideration (1) the adequacy of existing facilities under existing and future conditions from both structural and service aspects, (2) future conditions likely to prevail, (3) advantage in terms of monetary benefits to the United States economy for providing navigation improvements, and (4) the costs of providing the improvements.

The Economic Study addresses (1), (2), and (3) of the above considerations and integrates the findings to result in a quantification

of benefits from navigation improvements in the form of the Niagara Canal in the United States between Lake Erie and Lake Ontario.

The existing facilities were determined, in simulation studies, to be adequate until the 1990 decade at which time non-structural improvements were considered to provide only short-term relief. The simulation studies demonstrated that major structural improvements should be made at or about 1990 to provide a continuance of unobstructed growth in waterborne traffic. The traffic levels representing the simulated demand conditions were examined in terms of savings in transportation charges (rates) computed as the net differential between waterborne transport as compared with other distribution alternatives. Total transportation savings represent an aggregation of unit savings for each commodity moving via the Lake Erie-Lake Ontario Waterway increased by the number of tons moved over the improvement period, 1990 through 2040.

In addition to the transport savings are benefits to existing traffic in the form of reduced operating costs through reduction in transit times made possible through the Lake Erie-Lake Ontario Waterway. This saving is computed by assigning the hourly operating cost to the with and without transit times, the difference being attributed to the improvement project. The two benefit categories, transportation savings in the form of added capacity traffic and reduced operating costs in transit times to existing traffic, make

up the total transportation related benefits added by the provision of the Lake Erie-Lake Ontario Waterway.

51. Economic Benefits. Benefits from transportation savings and reduction in operating costs are presented in this section as an application of the methodological approach outlined previously. The data and projections applied herein are discussed in detail in the Economics Appendix, Appendix D.

a. Traffic - Existing and Projected. Traffic between Lake Erie and Lake Ontario increased from 21.3 million tons in the pre-St. Lawrence Seaway year of 1958 to a high of 64.0 million tons in 1972. The base year traffic for this study is 1971 which represented 62.9 million tons at the Welland Canal. Traffic may be aggregated into seven homogenous groups: (1) grain and farm produce, (2) coal, (3) petroleum and products, (4) clay, cement, stone, sand and gravel, (5) iron ore, (6) other bulk commodities, and (7) general cargo. Appendix D presents a specific and general definition, respectively, of the commodity groups used in this report.

A breakdown of existing traffic utilizing the Welland Canal between Lake Erie and Lake Ontario was shown in Table 5. Of particular note is the high volume of traffic between the United States and Canada. Also of note is the increase in Canadian domestic traffic in recent years. Discussion of each commodity group is contained in Appendix D and is not reported herein.

Projections of future traffic developed in this study are summarized in Table 6. Iron ore and grain are projected to increase in terms of percentage of total U. S. Lake Erie-Lake Ontario traffic, while coal and general cargo experience a relative decline. Projections of Canadian traffic were also made for simulation input and are shown in Table 7.

b. Transportation Rate Analysis. An analysis of transportation rates was made for each port to port movement reflected in the existing traffic patterns and for projected future movements for which no transportation rate base is available. Published rates were collected from three major sources: (1) Department of the Army, Eastern Area Military Traffic Management and Terminal Service, (2) Maritime Administration, and (3) Steamship Lines and Agents.

Comparative transport rates were assembled for lake, inland (including inland waterway), and ocean legs for each interlake and overseas route. Least cost transportation rates involving direct Great Lakes waterborne connection between shipping and receiving ports of U. S. interlake, Canadian interlake, and overseas origin were compared with combination rates for alternate routing involving rail, barge, or truck direct delivery or delivery to West and Gulf Coast ports for transshipment.

Table 8 is a summary of the transportation rate analysis showing a number of individual rate comparisons for each commodity group and the weighted average differential favoring Great Lakes

TABLE 6

Summary of U. S. Waterborne Traffic Between Lake Erie and
Lake Ontario, 1971 Actual, and 1980, 1990, 2015 and 2040 Projected

	<u>1971</u>	<u>1980</u>	<u>1990</u> (000 tons)	<u>2015</u>	<u>2040</u>
Grain	8,629	11,000	13,500	20,000	26,000
Coal	9,241	10,500	11,500	14,000	16,000
Petroleum	477	600	750	1,250	2,000
CCSSG	1,811	2,200	2,750	3,800	5,000
Iron Ore	11,689	16,000	20,000	30,000	40,000
Other Bulk	2,120	2,600	3,100	4,450	6,000
Gen. Cargo	<u>9,330</u>	<u>10,500</u>	<u>12,000</u>	<u>16,000</u>	<u>20,000</u>
Total	43,297	53,400	63,600	89,500	115,000

TABLE 7

Total Canadian * Waterborne Commerce Between Lake Erie and
Lake Ontario 1960-71 Actual, and 1980, 1990, 2015 and 2040 Projected

(000 tons)

1960-65	-	10,399
1966-70	-	12,866
1971	-	18,759
1980	-	24,600
1990	-	30,400
2015	-	42,500
2040	-	55,200

*Includes Canada - Canada and Canada-Overseas; Canada-U. S. Traffic
include with U. S. Totals

TABLE 8

Average Savings Per Ton For Cargo Transiting On
Lake Erie-Lake Ontario Waterway Over Least Cost Alternative

Commodity Sub Groups	Alternative Origin/Destination Points Utilized in Rate Comparisons					Weighted Savings Per Ton
	Atlantic Ports	U.S. Great Lakes, Canadian & Overseas Ports	Inland Rates*	Ocean Rates**		
GRAINS:	17	14	16	67	82	1.81
Corn	1	5	5	32	28	0.81
Soybeans	1	7	4	18	18	1.12
Wheat	5	2	7	17	36	1.21
COAL	1	3	6	6	6	8.66
PETROLEUM PRODUCTS	1	4	5	9	9	6.72
CEMENT, STONE, SAND & GRAVEL	1	11	11	14	14	3.40
IRON ORE	1	15	2	15	15	2.41
OTHER BULK	17	43	35	102	117	4.12
GENERAL CARGO:	223	164	134	1,054	452	18.81
Iron & Steel Products	23	15	7	107	33	18.50
Chemicals	15	12	12	61	40	28.36
Food	49	47	39	263	149	15.37
Transportation Equipment	53	17	17	131	43	53.52
Machinery	74	49	41	357	134	33.18
Other Manufacturing	11	28	18	135	53	19.21
TOTAL ALL GROUPS	257	254	209	1,267	695	7.27

* Includes rail, truck and combination truck-barge.

** Includes overseas, Canadian and domestic. For overseas rates both direct ocean and laker ocean combinations were considered.

waterborne movements. A detailed discussion of the rate analysis is contained in Appendix D and in a separate supplemental volume entitled, "Inter-model Domestic and Overseas Waterborne Rate Analysis for Great Lake Area Commerce."

c. System Simulation. Traffic simulation was conducted for the Lake Erie-Lake Ontario Waterway featuring the following alternatives: Existing Welland Canal; Welland Canal with non-structural transit time improvements; structurally improved 4-Lock Welland Canal; and 4-, 5-, and 6-Lock Niagara River Canal with existing Welland Canal.

The first two alternatives feature the existing 7-Lock Welland Canal with lock dimensions of 800' x 80'. The last two were simulated with 1,200' x 110' lock dimensions.

The above alternatives were simulated using the traffic volume in Table 7 together with vessel size and mix in Table 9 and average daily Lake Erie-Lake Ontario transits shown in Table 10. Table 11 completes the input data and represents the service times used in simulation for both Welland and Niagara locks.

Simulation results were interpreted to conclude that rapidly increasing canal transit times in the 1990 decade without structural improvement would result in a practical capacity saturation of the existing Welland Canal. Transit times representing 200-300 minute

TABLE 9 .
FLEET COMPOSITION - PERCENTAGE DISTRIBUTION BY CLASS ^{1/}

	Class I (1'-399')	Class II (400'-730')	Class III (731'-1,150')
1970	10.0	90.0	0.0
1980	8.0	87.0	5.0
1985	6.0	84.0	10.0
1990	5.0	80.0	15.0
1995	4.0	71.0	25.0
2000	3.0	62.0	35.0
2010	1.0	54.0	45.0
2020	1.0	44.0	55.0
2030	1.0	34.0	65.0

Note: Data for 1970 are actual, for the others are projected.

^{1/} Representative of fleet-transit demand for each period, i.e., vessel transit distribution that would occur if physical system would permit.

TABLE 10

VESSEL TRANSITS - WELLAND CANAL 1970 ACTUAL, 1980-2030
PROJECTED ACCELERATED GROWTH CONDITIONS

Month		1970	1980	1990	2000	2010	2020	2030
April	Total	535	576	623	683	749	832	927
	Up	315	339	367	402	441	490	546
	Down	220	237	256	281	308	342	381
May	Total	920	991	1,074	1,178	1,293	1,439	1,604
	Up	441	475	515	565	620	690	769
	Down	479	516	559	613	673	749	835
June	Total	799	861	932	1,022	1,121	1,247	1,389
	Up	405	436	472	518	568	632	704
	Down	394	425	460	504	553	615	685
July	Total	842	907	982	1,077	1,182	1,315	1,466
	Up	425	458	496	544	597	664	740
	Down	417	449	486	533	585	651	726
August	Total	831	896	971	1,065	1,169	1,300	1,449
	Up	408	440	477	523	574	638	711
	Down	423	456	494	542	595	662	738
September	Total	851	917	994	1,091	1,197	1,331	1,483
	Up	430	463	502	551	605	673	750
	Down	421	454	492	540	592	658	733
October	Total	904	974	1,055	1,157	1,269	1,412	1,574
	Up	462	498	539	591	648	721	804
	Down	442	476	516	566	621	691	770
November	Total	863	930	1,007	1,104	1,211	1,347	1,502
	Up	418	450	487	534	586	652	727
	Down	445	480	520	570	625	695	775
December	Total	456	491	531	582	638	709	790
	Up	187	201	217	238	261	290	323
	Down	269	290	314	344	377	419	467
Yearly	Total	7,001	7,543	8,169	8,959	9,829	10,932	11,923
	Up	3,491	3,760	4,072	4,466	4,900	5,450	5,944
	Down	3,510	3,783	4,097	4,493	4,929	5,482	5,979
Avg. Daily		23.5	27.4	29.7	32.6	35.7	39.8	43.3
Avg. Monthly		705.0	838.1	907.7	995.4	1,092.1	1,214.7	1,324.8
Avg. Vessel Tonnage/Transit		8,980	10,340	11,500	12,150	12,600	12,800	13,000

TABLE 11

LOCK DATA FOR WELLAND - NIAGARA STUDIES
(Average Times of Operation in Minutes)

<u>Lock Elements</u>	<u>Direction</u>	<u>Class I</u>	<u>Class II</u>	<u>Class III</u>
A. MOVING ENTRY	Up	14	18	21
	Down	13	17	20
B. QUEUED ENTRY	Up	17	21	24
	Down	16	20	23
C. MOVING APPROACH ENTRY	Up	8	11	13
	Down	7	10	12
D. STATIONARY APPROACH ENTRY	Up	11	14	16
	Down	10	13	15
E. SHORT ENTRY	Up	8	11	14
	Down	7	11	13
F. LOCKAGE (PROCESS)	Up	8	8	9
	Down	8	8	9
G. CHAMBER EXIT	Up	4	5	6
	Down	4	5	6
H. THROAT EXIT	Up	3	4	4
	Down	3	4	4
I. RECYCLE	Up	6	6	6
	Down	6	6	6

Note: For definition of lock elements consult Appendix D.

increases over the present 650-750 minute average were experienced even under assumptions of non-structural improvements and a new 4-super lock Welland configuration. By adding the Niagara River Canal under simulated operation of separate parallel facilities, which included the existing 7-lock Welland, transit times were greatly reduced and remained fairly constant throughout the simulation period from 1990 to 2030. The conclusion reached through simulation is that: (1) major structural additions in the form of alternate locking facilities will be required at or about 1990 and (2) structural improvements in the form of twinning of the existing Welland or the addition of a parallel canal will provide the capacity required to efficiently handle the projected traffic demand through 2030, the last year for which simulation was conducted. This study analyzed only the benefits and costs of providing an alternate canal between Lake Erie and Lake Ontario in the United States via the Niagara River in the vicinity of Buffalo, NY. Since the Welland Canal is located completely in Canada, the alternative to provide twin locks at the Welland Canal is not within the latitude of the United States.

d. Benefits. The major benefit attributable to the Lake Erie-Lake Ontario Waterway is in the savings to waterway users over alternative modes of transportation. Assuming that Welland Canal capacity is reached in 1990, the corollary follows that additional

traffic utilizing the waterway beyond that point is a direct result of the improvement in transit time. Therefore, the difference in projected tonnage of United States traffic represented in net between the 1990 traffic of 63.3 million tons as shown in Table 12, and the 2040 traffic of 111.9 million tons is a measure of capacity added by the addition of the Lake Erie-Lake Ontario Waterway. The net of 48.6 million tons translated in terms of commodity mix represented in Table 6 and origin-destination transportation rate differential in Table 8 results in a gross average annual benefit of 91.2 million dollars discount rate 5.61 percent. An additional savings to Canadian users is not quantified in the benefit analysis. Another benefit is derived from savings due to reduced traffic delays. Figure 1 points out the projected transit times with and without the Lake Erie-Lake Ontario Waterway or its equivalent in the form of alternate service between Lake Erie and Lake Ontario. Without such alternative service, the 1990 traffic represented by the number of vessels transiting the Welland Canal is projected to incur large delays over the life of the canal which is considered in the 650 to 700 minute transit time for a one-way passage of the Welland Canal. It is concluded through simulation under the assumption of maximum structural canal improvements, is 860 minutes. The canal improvement represented by the Lake Erie-Lake Ontario Waterway with 5 locks, each 1,200' x 110', result in the lowering of average vessel transit time to 637 minutes in 1990, 665 minutes in 2010, and 725 minutes in 2040. At an average hourly operating

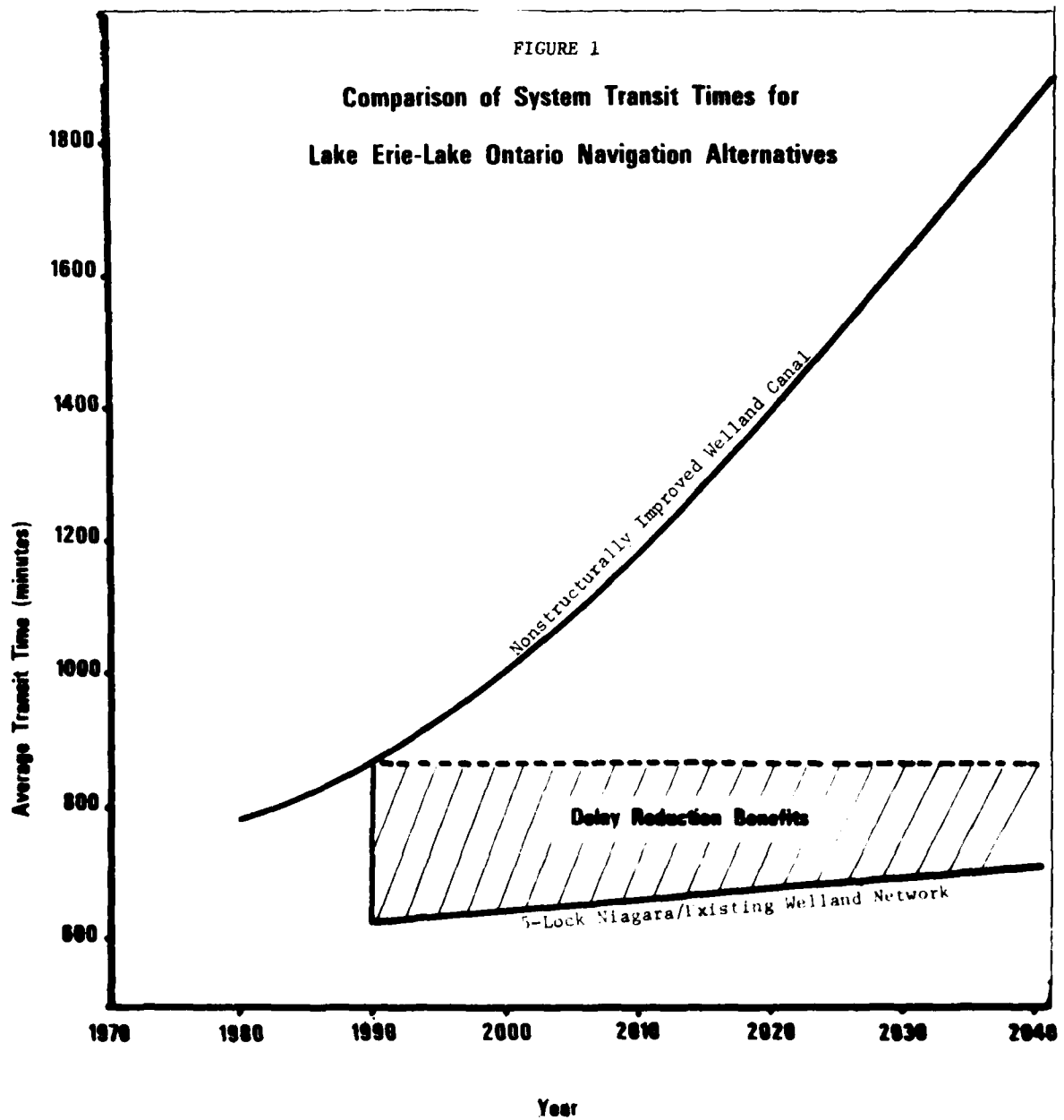
TABLE 12

Summary of U. S. Waterborne Traffic Between Lake Erie and
Lake Ontario, 1971 Actual, and 1980, 1990, 2015 and 2040 Projected

	<u>1971 *</u>	<u>1980</u>	<u>1990</u> (000 tons)	<u>2015</u>	<u>2040</u>
Grain	8,629	11,000	13,500	20,000	26,000
Coal	9,241	10,500	11,500	14,000	16,000
Petroleum	477	600	750	1,250	2,000
CCSSG	1,811	2,200	2,750	3,800	5,000
Iron Ore	11,689	16,000	20,000	30,000	40,000
Other Bulk	2,120	2,600	3,100	4,450	6,000
Gen. Cargo	9,330	10,500	12,000	16,000	20,000
Total	<u>43,297</u>	<u>53,400</u>	<u>63,600</u>	<u>89,500</u>	<u>115,000</u>

	<u>(Percent)</u>				
Grain	20	20	21	22	23
Coal	21	20	18	16	14
Petroleum	1	1	1	1	2
CCSSG	4	4	4	4	4
Iron Ore	27	30	32	34	35
Other Bulk	5	5	5	5	5
Gen. Cargo	22	20	19	18	17
Total	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>	<u>100</u>

* U. S. Army Corps of Engineers, Waterborne Commerce of the United States, 1971.



cost of \$300 per hour average annual benefits for savings in operating costs through reduced Lake Erie-Lake Ontario Waterway transit time is 6.2 million dollars discounted at 5.625 percent.

52. Net Benefits. As stated previously the assumption was made, for study purposes, that the St. Lawrence Seaway would present no constraints to future traffic movement. Projections of future waterborne traffic demands were developed, accordingly, including the years beyond 1990 during which a structurally improved Lake Erie-Lake Ontario Waterway was considered in place with locks of 1,200' x 110' compared with the existing Seaway Locks of 800' x 80'.

TABLE 13

TRAFFIC RELATIONSHIP BETWEEN ST. LAWRENCE SEAWAY AND WELLAND CANAL
1971
(000)

<u>Commodity</u>	<u>Welland Canal</u>	<u>St. Lawrence Seaway</u>	<u>Seaway % of Welland</u>
Grain	8,629	8,221	95.3
Coal	9,241	358	3.9
Petroleum	477	350	73.4
CCSSG*	1,811	931	23.8
Iron Ore	11,689	9,934	85.0
Other Bulk	1,520	1,185	78.0
General Cargo	<u>9,931</u>	<u>9,710</u>	<u>97.8</u>
Total	43,297	30,188	69.7

* Clay, Cement, Stone, Sand, and Gravel

Based on the projected increase in traffic between Lake Erie and Lake Ontario from 43.3 million tons in 1971 to 63.3 million tons in 1990 and 115 million tons in 2040, the assumption must also be made that the existing Seaway Locks will reach a capacity during the 1990-2040 period. This conclusion may be supported by examining the origin-destination pattern of Lake Erie-Lake Ontario Waterway traffic. As shown in Table 13, nearly 70 percent of the traffic in 1971 utilizing the Welland Canal also utilized all or portions of the St. Lawrence Seaway route. This is particularly true of grain and general cargo overseas traffic. Iron ore traffic from Labrador to U. S. Great Lakes ports also involves both St. Lawrence Seaway and Welland Canal transit. To further amplify the relationship between the Seaway and Lake Erie-Lake Ontario subsystems, an analysis of future Lake Erie-Lake Ontario traffic was made on a commodity by commodity basis to determine corollary traffic demand at the locks of the St. Lawrence Seaway. Since the Seaway Locks are of the same dimensions as the existing Welland Canal, the assumption was made that a reasonable measure of capacity for the Seaway could be equated with the level of capacity for the Welland Canal determined through computer simulation and described in Appendix D. Using this comparison, the St. Lawrence Seaway Locks were considered to reach capacity at or before 2010, and hence the benefits for system traffic beyond that point to the end of the study period in 2040 are divided

between the Lake Erie-Lake Ontario Waterway and St. Lawrence Seaway
lock facilities. Transportation savings are thus divided accordingly:

<u>Total Average Annual Transpor- tation Savings</u> ($\$$)	<u>LE-LO</u> ($\$$)	<u>Seaway</u> ($\$$)
91,200,000	70,300,000	20,900,000

The net traffic related savings for the Lake Erie-Lake Ontario Waterway
from U. S. traffic for the period 1990-2040 are summarized as:

TABLE 14

AVERAGE ANNUAL LE-LO TRANSPORTATION BENEFITS

<u>Total</u> ($\$$)	<u>Transportation Savings</u> ($\$$)	<u>Reduced Operating Costs</u> ($\$$)
76,500,000	70,300,000	6,200,000

ENVIRONMENTAL CONSIDERATIONS

53. Introduction. Environmental studies showed that the construction and operation of the proposed Lake Erie - Lake Ontario Waterway would result in a number of impacts on the social and ecological environment. Table 15 is a matrix that displays the most pronounced of these impacts. Inevitably, a project of this magnitude will result in significant effects upon the surrounding area; however, many of these impacts can be minimized and others, although difficult to mitigate, are considered, by the environmental consultant, acceptable minor effects. Table 16 "Summary of Unavoidable Adverse Impacts", indicates by asterisk the impacts that could be reduced but not totally eliminated. Appendix E, "Impact Assessment and Environmental Plan" discusses the environmental considerations in detail. For study purposes, the impacts were covered in four major categories: physical and chemical; ecological; social; and recreational and cultural. Each category has several components. In turn, each component has several indicators that comprise the key level of the study. Detailed information was collected for each indicator selected as an important aspect of the environment.

The most significant impact appears to be in the social category, due to acquisition of homes and disruption of established community patterns along the overland section.

TABLE 15
ASSESSMENT OF ENVIRONMENTAL IMPACTS

Evaluative Factors	Some		No		Some	
	Adverse	Adverse	Unknown	Effect	Beneficial	Beneficial
1. Physical and Chemical Environment						
A. Land						
(1) Physiography (Roads, Bridges, and Railroads)		X				
(2) Soils (No additional borrow areas required)				X		
(3) Geology (Blasting, Crushing, and Hauling)	X					
B. Water						
(1) Stream Flow Variations		X	X			
(2) Groundwater Hydrology		X	X			
(3) Temperature		X		X		
(4) pH				X		
(5) Turbidity and Total Dissolved Solids		X				
(6) Dissolved Oxygen		X		X	X	
(7) Fecal Coliforms				X		
(8) Toxic Substances		X				
(9) Inorganic Nutrients		X		X		
C. Air						
(1) Pollution During Construction	X					
(2) Pollution After Construction		X				
D. Noise						
(1) During Construction	X					
(2) After Construction		X		X		
2. Ecological Environment						
A. Terrestrial Ecosystems						
(1) Natural Vegetation		X				
(2) Crops		X				
(3) Dominant Herbivores		X				
(4) Migratory Species		X			X	
(5) Small Game Animals		X				
(6) Rare and Endangered Species				X		
B. Aquatic Ecosystems						
(1) Vegetation				X		
(2) Zooplankton				X		
(3) Benthos		X				
(4) Fishes			X			
(5) Pest Species				X		
(6) Rare & Endangered Species				X		
3. Social Environment						
A. Socio-economics						
(1) Employment Base					X	
(2) Population Growth			X			
(3) Income Levels & Distribution					X	
(4) Unemployment Rate			X			
(5) Public Services			X			
(6) Public Service Revenues		X				
(7) Property Taxes		X				
B. Social						
(1) Community Characteristics and Patterns			X			
(2) Relocation of People and Businesses		X	X	X		
(3) Historical Atmosphere of Bergholtz		X	X		X	
(4) Barrier due to Transportation Blockage		X				
4. Recreational and Cultural Environment						
A. Educational/Scientific Packages						
(1) Unique Natural Features			X		X	
(2) Unique Cultural Features			X		X	
B. Recreation						
(1) Recreational Supply		X			X	
(2) Recreational Demand		X			X	
(3) Secondary Effects of Recreational Activities						X
(4) Aesthetics		X			X	

TABLE 16
SUMMARY OF UNAVOIDABLE ADVERSE IMPACTS

-
-
- *1. Noise
 - *2. Air pollution
 - *3. Disruption and relocation of transportation routes
 - 4. Turbidity and temperature increase in Lake Ontario
 - 5. Loss of natural vegetation
 - *6. Loss of cropland
 - 7. Loss of wildlife
 - 8. Displacement of wildlife
 - 9. Loss of aquatic biota
 - *10. Social barrier via transportation blockage
 - *11. Change in population makeup due to influx of construction workers
 - *12. Relocation of individual residences and business
 - *13. Disruption of historical atmosphere of Bergholtz
 - *14. Loss of existing recreational acreage
 - *15. Loss of proposed recreational acreage
-
-

*Indicates plan has achieved some reduction in impact but not elimination.

ATTEMPTS TO MITIGATE THE UNAVOIDABLE ADVERSE IMPACTS

54. Noise. There are few alternatives that can reduce the noise generated by the construction and operation of the canal. Construction schedules should be designed to use only the daylight hours, avoiding the sensitive nighttime hours. Weekend construction activities should be minimal especially near recreation facilities that are likely to be used extensively. Temporary access roads used for hauling materials should be routed to avoid sensitive areas such as schools and residential communities. During operation of the canal, it is expected that the low speeds of the ships and boats using the canal will keep noise levels low. The use of horns or bells by the ships should not be permitted except in emergencies.

The noise generated in residential areas by the rerouting of the Penn Central-Erie Lackawanna Railways can be effectively reduced by routing these tracks to the east, rather than south, to join with the lines connecting North Tonawanda with Lockport.

55. Pollution. Construction vehicle traffic can create a dust and a combustion product emission problem. Regular wetting of temporary access roads used for hauling materials will reduce the fugitive dust problem. Paving or oiling should not be done on temporary roads because of the difficulties in reclamation at the end of construction. Use of vehicle emission control devices will result in minimal emission. Some increase over the ambient air pollution levels cannot be prevented simply because of the magnitude of construction vehicle traffic.

Vegetation removed from the canal right-of-way and construction debris should not be processed by open burning. Controlled incineration or proper disposal in a sanitary land fill will reduce air emissions during construction.

During operation of the canal the majority of the emissions to the air will result from the ships using the canal. The low operating speeds and the use of emission control devices on the engines are expected to minimize this impact.

56. Disruption and Relocation of Transportation Routes. While ten existing roads will deadend at the canal, these roads carry comparatively little traffic and will be connected to routes that cross the canal. The construction of more bridges will create additional noise, aesthetic, and relocation impacts. The proposed LaSalle and Belt Expressways and the Lake Ontario State Parkway can cross the canal using a new bridge in the case of the expressway and tunnel for the parkway. Refer to the Environmental Appendix E for further details.

57. Turbidity and Temperature Increases in Lake Ontario. The dredging of the Niagara River channel for the canal will cause some unavoidable but temporary increase in turbidity. Materials from the cutting of the channel in the overland section will not be dumped in the lake, but used in the construction area, thus causing no increase in turbidity.

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Temperature increases in Lake Ontario will be small and have no significant effect on aquatic life.

58. Loss of Natural Vegetation. The Lake Erie - Lake Ontario Waterway will unavoidably remove small quantities of natural vegetation. Rerouting the canal would not significantly alter this impact. The existing route was planned to avoid the Tuscarora Indian Reservation where much of the natural vegetation in the Western portion of Niagara County is located.

59. Loss of Cropland. The predominant agricultural lands affected by the Waterway are orchards and vineyards, pasture, and highly productive vegetable cropland. Because of the expanse of orchards, vineyards, and pasture in Niagara County, little can be done to reduce the acreage removed by the canal.

The productive, well-developed, vegetable cropland is localized, and the acreage affected by the canal can be significantly reduced by a minor routing of the canal. With realignment, the canal will pass along the edge of this cropland, rather than through the center. To further mitigate adverse impacts on this cropland, a means of controlling the drainage of soil moisture into the canal should be developed that is compatible with the existing and proposed tile drainage system for these soils. Techniques include sealing the soil near the canal edge to prevent seepage, controlled pumping of water from the canal into the soils to replace lost moisture, and using a drainage tile system, that discharges into the canal, and a gate to channel and control the seepage. Consultation with the Soil Conservation Service during the design phase of the waterway would insure the selection of the best alternative.

60. Loss of Wildlife. The removal of natural vegetation and agricultural land constitutes a loss in wildlife habitats and a corresponding unavoidable loss of wildlife that rely on this land for breeding, feeding, and nesting or denning.

The surge basins and canal will provide some additional habitat for a waterfowl resting area. The planting of appropriate emergent aquatic vegetation along the margins of the surge basins would improve this habitat for waterfowl. However, the turbulence in the surge basin as water enters or leaves and the fluctuating water level are not expected to permit the basins' development into high quality waterfowl habitats.

61. Displacement of Wildlife. During construction, the presence of large numbers of workers, vehicular traffic, and noise will displace wildlife located near the canal. Measures, short of drastically reducing the size of the construction force, will do very little to reduce this impact.

62. Loss of Aquatic Biota. The dredging required for the Niagara River channel and the harbor out into Lake Ontario will destroy rooted aquatic vegetation and benthic organisms located in the dredged areas. Toxic sediments stirred up during dredging may kill some fish and plankton. These impacts are unavoidable.

63. Social Barrier via Transportation Blockage. A barrier imposed on transportation and interaction networks by the waterway is unavoidable. The eight crossings provided, however, will minimize the social impacts.

To improve this network, the temporary access road on the east side of the canal could be converted, at the end of construction, into a paved parkway that would improve the north-south highway system. In so doing, care should be taken that significant construction impacts are not incurred in the building of this route.

64. Change in Population Makeup Due to Influx of Construction Workers.

Short of hiring most of the construction workers locally, this impact is unavoidable. It is doubtful that the area could, under normal circumstances, supply several thousand construction workers. However, it is suggested that, when possible, the Corps should encourage its contractors to employ local labor in order to provide beneficial impacts upon those affected by the proposed developments.

65. Relocation and/or Damage of Individual Residences and Businesses.

Recognizing that these impacts represent a subject that has been dealt with inadequately in the past, it is suggested that in addition to, or in lieu of, the usual realtor-defined value determination of condemned property, a commission be established with representatives from the local community, the Corps, HUD, or other pertinent housing or agricultural agencies, to insure that a fair settlement and sufficient payment and options should be made available to local residents forced to relocate as a result of development of the canal project. The Corps should be willing to move present houses to new sites if that is the desire of present residents.

It is suggested that a bond be put up either by the Corps or, required of their respective contractors, to insure that there will be mechanisms and dollars available to compensate local citizens for damage incurred as a result of canal-related activities. Particularly, these monies should provide compensation for structural damage to dwelling units impacted by construction, as well as such things as temporary housing of residents forced to relocate during canal construction activities.

66. Disruption of Historical Atmosphere of Bergholtz. The disruption of the historical atmosphere of Bergholtz by the canal can be reduced to some extent by the planting of tall trees along the canal edge to shield the community from the sight of the canal. A portion of this atmosphere might be captured in the canal visitor center using an interpretive historical narrative, as well as an example of clothing, tools, etc., representative of the era when Bergholtz was settled.

67. Loss of Existing Recreational Acreage. Loss of land in Riverview Park for canal construction could be ameliorated by acquiring adjacent land, including that now occupied by the highway and railroad scheduled for relocation if the canal is constructed. The loss of park acreage at Bond Lake could be prevented if the surge basin were placed on the east rather than the west side of the canal. New park lands may be acquired to compensate for the loss or substantial reduction of Oppenheim Park.

68. Loss of Proposed Recreation Acreage. Damage to the proposed park along Sixmile Creek could be minimized by careful location and construction of the tunnel carrying Youngstown Road and the proposed Lake Ontario

Parkway under the canal. No specific amelioration can be suggested for the loss of proposed recreational open space on Squaw Island except for acquisition of an equivalent site for the proposed Squaw Island high school campus, including a playing field-sports area.

Interruptions in east-west open space corridors, such as the proposed Niagara Escarpment Trail and the Cayuga-Bergholtz Creek corridor, can be minimized if hiking-biking space is specifically provided in the bridge facilities carrying Upper Mountain Road and Route 62 over the canal. The attractiveness of these corridors will remain somewhat reduced due to the close association with highway traffic.

69. Recreation and Other Needs. The impacts discussed below are anticipated as a result of the construction and operation of the Lake Erie-Lake Ontario Waterway during the period 1990 to 2030. Impacts of recreational facilities built in conjunction with the canal are specifically excluded. Impacts such as those resulting from necessary highway relocations are included.

a. Recreational Supply. Five types of impacts on recreation supply are identifiable. They are: (1) direct loss of recreation facilities; (2) increased carrying capacity for boating; (3) reduced carrying capacity for fishing; (4) capacity changes due to altered aesthetics; and (5) reduced access to recreation facilities.

(1) Direct loss of recreation facilities - These impacts result

when the canal itself, its construction, or highway relocations preempt recreation lands. Five such preemptions are identifiable.

A 150-acre open space area on Squaw Island proposed for 1971-1980 development as a high school athletic area would be largely destroyed by construction of a canal and lock on the Island. The proposed recreation facility would serve the immediate Buffalo area only.

A portion of the existing Riverview Park in North Tonawanda would be taken for the canal entrance from the Niagara River. Construction activities would displace nearly all park use until canal completion. The site currently contains 53 acres with a 47-acre addition proposed. Relocation of the River Road and abandonment of the adjacent railroad would present new opportunities for expanding the park area. On the other hand, the high bridge required for River Road over the canal would have a visual and possibly a noise impact upon the park. The significance of the impacts cannot be readily estimated at the present time. The net effect may be beneficial, however, since current highway and rail traffic detract considerably from a park-like atmosphere.

Much of Bond Lake Park (currently 561 acres, with a proposed 130-acre addition) would be inundated by a surge basin on the Niagara Escarpment. Over \$4 million of developments are currently planned for the area, including nature centers, boating areas, hiking-biking trails, day camp areas, a swimming pool, and a golf course. Loss of any substantial portion of this park would be a significant regional impact.

A proposed 200-acre Town park on the Lake Ontario shore at Six-Mile Creek would be affected by relocation of Youngstown Road and State Route 18 and construction of their tunnel under the canal. This is a regionally significant area proposed to serve mainly fishermen and picnickers.

As previously mentioned, impacts of recreational facilities built in conjunction with the canal have been excluded.

(2) Increased carrying capacity for boating - Increased water surface area provided by the canal would increase capacity for boating, while providing them with the unique experience of traveling from Lake Erie to Lake Ontario through the massive locks. The presence of large ocean-going vessels on the upper Niagara River and in the canal could enhance the pleasure and increase the activity of boaters in this area, since large vessel traffic would not interfere with the smaller boats and would provide recreationists with an awesome sight. Any adverse impacts to existing boating sites along the river are expected to be of only minor significance.

(3) Reduced carrying capacity for fishing - Reduced water quality due to turbidity during dredging of the river channel may decrease the sport fishing potential of several sites during canal construction. Potentially impacted areas include: Beaver Island State Park; Riverview Park, North Tonawanda; the Six-Mile Creek area on the Lake Ontario shore; and the upper Niagara River in general.

Very little turbidity is expected in the river during canal operation. If projected water quality standards are met and discharges from ships are carefully controlled, these impacts should be small. The increase in water temperature in the immediate area of the canal outflow into Lake Ontario may locally increase the fishing potential of the area.

(4) Capacity changes due to altered aesthetics - Portions of the canal will be significantly below or above ground surface. In an area of primarily flat terrain (excepting the immediate escarpment area), the visual impact on recreation areas may in some cases be substantial. The aesthetic appeal of the Oppenheim Park area, for example, will be reduced by the intrusion of the canal and its ship traffic in a park setting. Similar visual intrusions may affect proposed facilities at the Six Mile Creek Park, on Strawberry Island, along the Lake Ontario Parkway, and along the Niagara Escarpment trail. At the escarpment, the impact on the trail and on Bond Lake may be particularly dramatic since the canal will be diked and above grade. In most cases, impacts of this type will detract from the recreational value of park areas. There may be exceptions, however, when the canal and its associated traffic add interest to a scene and may make areas more popular for picnicking. Impacts of this latter type are assumed to generally imply transfers of use from alternative sites in the region, as described in the section on Displaced Recreation Demand.

(5) Reduced access to facilities - The waterway will serve as a

north-south barrier, limiting access to some sites. Continuous open space corridors such as the Niagara Escarpment trail and proposed corridors east and west from Oppenheim Park will be particularly affected. If adequate crossings are not provided to permit horse, foot, and bicycle traffic, these corridors will be substantially reduced in value. The canal construction phase may be particularly disruptive to corridor use.

b. Recreation Demand.

(1) Newly created demand - The proposed canal may directly increase the demand for recreational opportunities by attracting new tourists to the area, encouraging longer stays, and increasing the resident population through the work force required for construction and operation.

The recreation demand impacts of new residents are expected to be moderate when concentrated in a single locale. A peak construction work force of 5,000 people and an operating force of 500 are expected for the canal. It is possible that part of the work force can be recruited locally (Erie and Niagara Counties). The maximum size of their recreation impact can be anticipated by assuming that all come from outside the region. Allowing for the workers and their families, new service occupation workers and their families, the maximum anticipated Niagara County population increases may be roughly 15 to 20 percent, with a corresponding increase in recreation demand. This

demand will be of greater significance if these temporary population increases concentrate within the county. These calculations represent maximum possible impact. To the extent that local people fill the construction and service jobs, the actual impact will be reduced from this maximum. These population changes may result in heavy temporary stress on local park facilities.

(2) Displaced recreation demand - The changes in recreation facility supply discussed above will result in the displacement of recreation use, creating increased demand on remaining facilities. The activities most likely to exhibit such displaced demand include water-based activities, such as fishing and boating and recreation corridor uses, such as hiking, bicycling, and horseback riding.

An opposite type of demand shift may occur for picnicking as a result of the canal. Canal traffic may add interest to adjacent facilities and attract users who would otherwise picnic at other locations within the region. Areas that may experience increased use of this type include: Strawberry and Motor Islands; Veteran's, Niawanda's, and Isle View Parks in Tonawanda; La Salle and Front Parks in Buffalo; Riverview Park in North Tonawanda; and Oppenheim Park in Wheatfield. This type of new use may be especially noticeable at recreation areas near the ends of the canal or near locks; specifically, Riverview Park, Six Mile Creek Park, and Bond Park.

The above impacts on recreation demand assume no recreational

development associated with the proposed Lake Erie-Lake Ontario Waterway. To the extent that related facilities are developed, other demand shifts may occur from a variety of sites in the region.

c. Recreational opportunities offered by the canal - The canal and its associated facilities present several opportunities to develop new recreational facilities, including the following:

(1) A scenic parkway along the east shore of the canal could connect the proposed La Salle Expressway to Lake Ontario Parkway. The access and haul roads used during construction could be developed for this use.

(2) A hiking-biking corridor could parallel the west shore of the canal, providing an important north-south link between proposed east-west corridors such as the Niagara Escarpment Trail and the Cayuga-Bergholtz Creek corridor.

(3) A new hiking-corridor could be developed on the railroad right-of-way to be abandoned between Riverview Park and Walmore.

(4) A visitor center and observation area could be developed to interpret canal operation and local features of historic or natural interest. A location near Lock 4-5 on the escarpment would be an effective focal point for visitor interest.

(5) If the canal operations center is located near either canal endpoint or at a lock, a second visitor center area could be developed, including tours of the canal operations control room.

(6) Canal breakwaters into Lake Ontario could be developed to accommodate fishermen. Moorings might also be provided for pleasure

craft on the outside of the eastern breakwater.

(7) Fishing in surge basins could be aided by provision of minor facilities for improved public shore access.

(8) Picnic-observation areas could be located at the Lake Ontario shore and at any other points of interest, such as near locks and surge basins when canal design permits.

(9) Canal dikes could be landscaped to facilitate sledding use. In the escarpment area, cut material might be used to shape a short ski slope.

(10) If the canal route were shifted to the east in the Bond Lake area and if the surge basin were placed on the east side, additional land could be developed, particularly for camping, adjacent to the Bond Lake Park.

70. Other Water and Related Land Resource Needs. The waters of the Niagara River, Lake Erie, and Lake Ontario and the land adjacent to the considered Waterway are used for a variety of purposes that satisfy human needs, but which, in turn, have created a variety of problems. The considered waterway would influence and be influenced by these needs and problems.

The water resources serve as the principal water supply for the area, both municipal and industrial. The lakes and river are important transportation arteries and prime recreation resources, providing opportunities for recreational boating, sport fishing, and swimming.

The Niagara River is a major producer of hydroelectric power. Finally, the waterways are used extensively as a means of waste disposal.

Many of the problems with area water resources relate to its use for waste disposal. Industrial and municipal discharges are not fully treated and have caused degradation of water quality, reducing its attractiveness for recreational use and resulting in problems of water supply. Treatment and remedial measures are being installed, and water quality is expected to improve.

Land resource uses and problems are related to those of water resource. The land area along the route of the considered waterway is basically an urbanized area with industrial, residential, commercial, and recreational zones. Along the northern part of the route, near Lake Ontario, much of the area is used for agriculture, but suburban residential development is occurring along existing roads.

Land use problems include changes in uncontrolled urbanization, pollution due to lack of sewers in developing areas, and conflicts in future use such as recreational versus others and agricultural versus residential. Creation of a jetport in the area could create numerous problems in land use. Because much waterfront land is privately owned, with limited public access, conflicts arise among residential, commercial, and industrial use.

PLAN OF IMPROVEMENT

71. General Description. The proposed waterway will connect Lakes Erie

and Ontario via a navigable channel. Details of the proposed plan of improvement are shown on Plates 1 through 12. It will consist of two sections, the Niagara River section, from Lake Erie down river to the north side of North Tonawanda, and the overland section, from the Niagara River north to Lake Ontario. There will be a harbor on Lake Ontario at the canal entrance. The proposed waterway will become an integral part of the Great Lakes-St. Lawrence Waterway System that allows not only shipping between the Great Lakes, but also provides for the transit of ocean-going ships from the North Atlantic to ports on Lake Superior. See Appendix A for detailed description of the proposed plan and other waterway routes considered between Lakes Erie and Ontario.

72. Basic Criteria. The proposed waterway will have a minimum bottom width of 600 feet to meet standards for two-way traffic and a minimum channel depth of 30 feet. The proposed plan of improvement does not provide the minimum width in all reaches of the waterway initially, but does make design provisions for future widening of the substandard reaches. The proposed waterway in the Niagara River will have a width of 600 feet upstream of the Black Rock Lock and 700 feet downstream. The overland section will be 500 feet wide south of the Niagara Escarpment 700 feet wide north of it. There are exceptions to the widths, as noted above and in Appendix A. Minimum waterway depth will be 30 feet in canal channels and 35 feet at lock sills, and minimum vertical clearance will be 120 feet. The locks will be

110 feet wide by 1,200 feet between gates and will permit passage of a maximum size vessel of approximately 105 feet by 1,000 feet.

Practical lockage time for the large ships will be approximately 40 minutes, as noted in Appendix D. Water for the lockages will come from the Niagara River. Using a minimum assumed lockage time, Appendix C indicates a maximum average daily water requirement of 2,930 cubic feet per second during the peak summer months of canal operations.

Electric power for canal operations will come from the Niagara Mohawk Power Co. through their generating facilities on the Niagara River. Each lock will be provided with an emergency power source capable of supplying normal operating power demand in the event of a power failure.

The plan of improvement as presented is not optimum, but is considered to be a workable plan with practical solutions for all technical difficulties encountered. Further and more detailed analysis will be required to determine an optimum plan fully cognizant of the effects of environmental, economic, structural, hydraulic, and recreational considerations.

73. Niagara River Section. Details of the proposed waterway in the Niagara River section are shown on Plates 2 through 6. The existing Lake Erie approach channel to the waterway is 800 feet wide

and will be deepened to 30 feet. The new 600 foot wide by 30 foot deep canal channel will generally follow the alignment of the existing Black Rock Canal from Lake Erie to the new Lock 5-5 at Black Rock. From Lock 5-5 north to the entrance of the overland section, a point just north of the city of North Tonawanda, the waterway will be 700 feet wide by 30 feet deep. There will be a local narrowing of the waterway to 400 feet at the South Grand Island Bridge and a local widening to 800 feet at overland section entrance. The new Lock 5-5 will be adjacent to the existing Black Rock Lock. It will be 110 feet wide by 1,200 feet between gates and will provide for a 5-foot lift. The new 600-foot wide and 30-foot deep canal channel upstream of Lock 5-5 will require the relocation of existing Bird Island Pier to the west, restricting the Niagara River flow at this point. As described in Appendix A, compensation will be required in the area to maintain Niagara River stage flow relationships.

Disposal of excess dredged materials will be in the open lake at depths of 40 feet or more, except that materials dredged from Ontario Harbor could be deposited below project depth in the deeper areas of the harbor. Appendix E presents evidence that polluted sediments are present in the existing Black Rock Canal and along the east shore of the Tonawanda channel of the Niagara River. It is anticipated that polluted sediments in the existing canal will be removed, or at least minimized by normal Corps of Engineers

maintenance dredging, and that the location of the new canal in the Tonawanda channel will avoid dredging of appreciable amounts of polluted materials in that area. Should appreciable amounts of polluted materials be encountered, disposal would be in contained diked disposal areas or other acceptable means. Appendix A provides additional details on quantities, use, and disposal of excavated materials.

The new waterway depth and horizontal and vertical clearance requirements will necessitate many bridge and utility relocations along the Niagara River. Plates 2 through 6 show the location and type of relocations in the Niagara River section of the canal. A new Peace Bridge, parallel to the existing bridge, will be constructed at a higher elevation. A railroad bascule span will be required across new Lock 5-5 in the present approach to the International Railroad Bridge. The South Grand Island Bridges will be raised vertically to secure required clearance. The Squaw Island Waste Treatment Plant will be relocated. The flyash lagoons for the city of Buffalo incinerator will be relocated. Submarine water intakes for the cities of Buffalo, Tonawanda, North Tonawanda, and Lockport will be rebuilt at lower elevations. A submarine gas line crossing north of the South Grand Island Bridge will be relaid at a lower elevation. Three submarine communication cable crossings must be lowered. Several communication cables on Squaw Island must be relocated through the new Lock 5-5. Overhead power lines crossing the river north of

the South Grand Island Bridge must be raised. River sampling facilities on Squaw Island will be relocated. Additional information relative to the above relocations is outlined in Appendix A.

74. Overland Section. This section of the waterway will extend from the Niagara River north of the town of North Tonawanda, overland in a northerly direction to Lake Ontario. Details of the proposed waterway in the overland section are shown on Plates 7 through 10. The channel will be 500 feet wide by 30 feet deep, north of the lock. There will be four locks in this section, each of which will be 110 feet wide by 1,200 feet between gates and will provide for a lift of 80 feet. The locks will be offset from the channel centerline to allow for future twinning. Lock 4-5 will be located at the Niagara Escarpment, approximately half way between the Niagara River and Lake Ontario with the other locks spaced at intervals to Lake Ontario.

For lockage, surge basins will be required to minimize water surge in the channel due to the filling and emptying operations of the locks. Surge basins will be located adjacent to each of the channel reaches between Locks 4-5 and 3-5, 3-5 and 2-5, 2-5 and 1-5, and southwest of Lock 4-5 at the base of the Niagara Escarpment. Except for the emptying of Lock 1-5, Locks 1-5 through 4-5 are filled from and emptied into these surge basins. Each canal channel is connected to the adjacent surge basin by 100-5 foot diameter flow

restricting culverts. Based on this restricted flow, the surge basins are designed to provide sufficient surface area relative to the surface area of the canal channels to permit rapid emptying and filling of the locks without producing unsafe surge heights in the canal channels. Appendix C provides additional information on the hydraulic design of the surge basin and culverts.

In the overland section, the waterway will interrupt numerous roads, railroads, and utilities. Plates 7 through 10 show the location and type of relocations in the overland section of the canal. According to the criteria delineated in Appendix A, the roads and railroads will be relocated either through tunnels in the upper miter sills of the locks, or on high level bridges over the waterway, or will be detoured permanently on new or existing routes. The utilities will be relocated in basically the same manner. The Erie Lackawanna Railroad and the New York Central Railroad-Niagara Falls Road Branch line will be located over twin, adjacent, high-level cantilever bridges. The New York Central Railroad-Ontario Branch line will be relocated through a tunnel in the upper miter sill of Lock 2-5. There will be new high level suspension bridges over the waterway for River Road, La Salle Expressway, Niagara Falls Boulevard, Lockport Road, Saunders Settlement Road, and Upper Mountain Road, Ridge Road, Youngstown-Lockport Road, and Lake Road-Youngstown Road will be relocated through tunnels in the upper miter sills of Locks 3-5, 2-5, and 1-5, respectively.

Excess excavated material will be deposited in the naturally overdeep surge basins and channels between Locks 4-5 and 3-5 and Locks 3-5 and 2-5 as necessary.

Each lock will contain public use facilities on the lock esplanade, including parking facilities, observation area, and an operations building.

75. Lake Ontario Harbor. There will be a harbor on Lake Ontario at the entrance to the waterway, providing 1,650 acres of water surface, 30 feet deep minimum, enclosed by a stone rubblemound breakwater with an arrowhead entrance. The harbor will form a sheltered area at the channel entrance for the temporary mooring of ships waiting to transit the waterway.

MAINTENANCE AND OPERATING FEATURES

76. Introduction. There will be an area complex, adjacent to the waterway and Lake Ontario, in the vicinity of Lock 1-5, which will contain the Administration Building, Traffic Control Facilities, Maintenance and Warehouse Building, and the Mooring Basin for marine equipment. There will also be a smaller maintenance building and facilities at each lock.

The centralized traffic control facilities will be equipped with a closed-circuit television system for lock and channel monitoring, a computerized control console, a computer for instant data on a particular ship, and both audio and telemetry communications with each lock.

The mooring basin will contain marine equipment for channel and lock maintenance, such as gate lifter, scows, tugs, barges, and survey boats.

Appendix A provides additional information and details relative to the maintenance and operating features.

77. Recreational and Environmental Features. The cost of recreational features included in the plan-of-improvement estimates of first costs include a visitor center located on the Niagara Escarpment, a scenic parkway parallel to the overland channel (running from the Niagara River to Lake Ontario Harbor), small boat marina facilities at the harbor, and various other parks and recreational features. The costs of suggested revisions to mitigate adverse environmental impacts are not considered in the estimates of first costs.

78. Shoreline Changes. The construction of the harbor at the Lake Ontario end of the waterway will have some impact upon the shoreline in the immediate area. The shoreline in the area is essentially straight, oriented in an east-northeast direction from the mouth of the Niagara River, about seven miles westerly of the harbor site. Bluffs along the shoreline rise 15 to 20 feet above the normal lake surface. Bluff material is generally glacial till. There is usually a narrow beach 10 to 20 feet wide at the base of the bluff, mostly

gravel with some sand. Bedrock is generally below the base of the bluff.

Littoral drift in the area is from west to east. However, most material eroded from the bluffs is fine silts and clays, with only a small percentage of gravel or sand-sized particles. A report on a beach erosion study of Niagara County, completed in 1942, concluded that only a minor portion of the material obtained from the eroding portions of the shoreline became a part of the beaches, almost all of the material being carried into deep water.

Construction of the harbor structures would protect the shoreline within from further erosion. The breakwater shore arms would extend to shore and act as a littoral barrier. As the littoral drift is from west to east, the westerly arm would collect some beach material on the westerly side. This would eliminate the supply of beach material to the area east of the easterly shore arm. However, since the supply of material is small, only a minor amount of accretion will occur to the west and the erosion to the east would be slight.

There would be no effect on the Lake Erie shoreline, as the channels follow existing project channels, and no new structures are required.

79. Aids to Navigation. Plans for aids to navigation were developed in conjunction with the U. S. Coast Guard. Most work would be in

connection with the Lake Ontario harbor. One major light station would be required on the ends of the breakwaters. Some additional buoys and range lights might be required along the Niagara River section. Above the new lock at Squaw Island, no new aids would be required. At the Lake Erie end, the channels would be along the existing Buffalo Harbor channels, and no additional aids to navigation would be required.

Traffic through the canals would be controlled by a traffic management system consisting of an audio-video monitoring control system and an automatic, computerized, data collection system, with central console display, to monitor all pertinent functional operations of the canal components and the location with the existing Canadian Marine Traffic Information and Control system would be mandatory to make the most efficient use of available Canadian and American facilities.

COSTS

80. First Cost. For this study the estimates of cost are somewhat approximate, since detailed studies of all of the principal features of the waterway were not made. Where detailed designs of structures, equipment, or other features of the waterway have not been made, costs of like items from similar projects were modified and adjusted to price levels of December 1972. All other construction costs were based on price levels as of that date. See Appendix A for details

of the cost estimates. The first cost of the waterway is \$2,237,600,000. The principal features of the estimate are listed in Table 17.

TABLE 17
ESTIMATE OF PROJECT FIRST COST

<u>ITEM</u>	<u>AMOUNT</u>
Lands and Damages	\$ 25,000,000
Relocations	582,000,000
Locks	690,000,000
Channels and Canals	529,000,000
Recreation Facilities	10,000,000
Lake Ontario Harbor	163,000,000
Operation and Maintenance Facilities	16,800,000
Total Construction Cost	\$2,015,800,000
Engineering and Design	60,500,000
Supervision and Administration	161,300,000
TOTAL PROJECT FIRST COST	\$2,237,600,000

81. Investment Cost. It is estimated that the project could be constructed in 5 years. This does not include time spent on design and assumes no monetary constraints. Interest during construction would amount to \$357,930,000 (5-5/8 percent for one-half the construction period) making the total investment \$2,595,530,000.

82. Estimated Annual Charges.

Annual charges are estimated as follows:

Interest 5-5/8 percent	\$145,999,000
Amortization 50 years at 5-5/8 percent	10,117,000
Operation and Maintenance	20,000,000
TOTAL ANNUAL COST	\$176,116,000

83. COMPARISON OF BENEFITS AND COSTS

The primary benefit category evaluated in the economic justification of navigation improvements is the savings to waterway users from the use of waterborne transportation, rather than the next least costly alternative or combination of modes. This savings was determined from a detailed transportation rate study for all commodities moving between Lake Erie and Lake Ontario, taking into account their initial origin and ultimate destination. The annual waterborne traffic benefits discounted at 5-5/8 percent were estimated to be \$76,500,000 (see Table 14). This does not include Canadian benefits nor other secondary effects. The resultant benefit to cost ratio using only transportation related savings would be 0.4 to 1 ($\frac{\$ 76,500,000}{\$ 176,116,000}$). The economic evaluation of a project of this nature is totally dependent upon assumptions of future volumes of traffic. Since this effort was a unilateral study, Canadian benefits (positive or negative) could not be considered. Further, under current guidelines, an economic comparison of alternative modes is the only acceptable method of arriving at benefits. Not taken into account are tangible and intangible benefits, derived from the interdependent aspects of the economy affected by such an action.

SECONDARY EFFECTS

84. Introduction. The benefits reported above, attributable to the Lake Erie-Lake Ontario Waterway, are defined as consisting only of

traffic, including origin, destination, origin-date and/or termination-date, and type of cargo. The following are related savings and costs of traffic: (1) cost differential between waterborne and landborne cargo, and (2) savings in operating costs of the reduced traffic volume and related at port facilities. The study also considers the initial impacts of the plan and a number of other related issues that will be discussed individually in this document. These subjects, as indicated, are: (1) use of the College of Arts.

(1) Impact on Canadian Traffic

(2) Impact on the Shortage of Water and Failure of the Waterway

(3) Impact on the

(4) Impact on the

(5) Impact on the Winter Season

(6) Impact on the Scheduling

(7) Impact on the Local and Regional Development

(8) Impact on the

85. Impact on the Shipping Traffic About 30 percent of the 1971 base year waterborne traffic involved Canadian origin-destination points of a domestic or Canadian-overseas nature. The Canadian share of waterborne shipping traffic is projected to increase slightly from 30 to 35 percent of all water traffic in the 1990-2040 period. The addition of the new waterway to 1971 would result in transportation relationships with the Canadian economy by increasing the capacity

of relatively low-cost waterborne traffic movements between the Prairie Provinces to the west and the highly industrial areas of Ontario and Quebec to the east. The major commodity groups involved in the Canadian LEO traffic are grain, iron ore, and petroleum. The grain moves from Lake Superior ports of Ft. William-Port Arthur to St. Lawrence River ports for both domestic consumption and export transshipment. Iron ore moves from the Labrador mines at Sept Isles to Canadian steel-making facilities at Lake Superior. Petroleum is distributed among Canadian ports both up and down the Great Lakes-St. Lawrence Seaway System. Using a rate schedule comparable to United States nearby destination points in the vicinity of Canadian ports for waterborne shipments, a weighted average of about \$1.70 per ton savings is considered realistic as a measure of waterborne savings over cost and constructed rates for rail-haul of Canadian traffic in grain, iron ore, and petroleum. Based on the traffic projections contained in Table 7, an annual benefit of about 21 million dollars would result to the Canadian economy in the 1990-2040 period as a result of the additional traffic capacity facilitated by the Lake Erie-Lake Ontario Waterway.

86. Insured Traffic Route Between Lake Erie and Lake Ontario. The Lake Erie-Lake Ontario Waterway as a separate parallel facility to the existing Welland Canal would provide a safety feature, in addition to the increase in traffic capacity and efficiencies achieved

from reduced traffic congestion. The LE-LO Waterway would provide insurance against a total blockage of traffic between Lake Erie and Lake Ontario in the event of a temporary short-term or major long-term debilitation of the existing Welland Canal. Although intangible in terms of potential frequency of occurrence of such debilitating circumstances, the value of an alternative route is measured by the probability of occurrence of a breakdown, which is increased with growth in traffic and the advancing engineering age of the existing Welland Canal constructed in 1932.

At an average daily arrival rate of 30 vessels in the 1990-2000 decade, a failure of the single facility Welland Canal for one day would result in a loss, from delay time alone, of over \$200,000 at an operating cost of \$300/hour. Projected on a weekly basis, delay cost would approach \$1.5 million per week, which does not include potential losses due to cargo spoilage, damage, or penalty of late delivery. A total debilitation for a full shipping season, calculated on the basis of rate differentials between waterborne and alternative modes, would result in an estimated increase of over 400 million dollars in transportation rates for U. S. traffic and over 80 million dollars for Canadian commerce at the 1990 level of traffic. The losses could double under demand conditions equivalent to the 2040 projected traffic. Not quantifiable is the possibility that other transport facilities may not be capable of absorbing such

an increment of traffic demand represented by a sudden long-term failure of the Welland Canal, resulting in major shortages for industry and inventory problems for U. S. agriculture.

87. Recreation. The considered plan of waterway improvement appears to have potential for providing recreational opportunities, with relatively modest additional development. The waterway would be in the Buffalo metropolitan area, where substantial demand for outdoor recreation exists. In addition, the waterway would be within a few miles of Niagara Falls, one of the major tourist attractions on the North American Continent, which attracts several million visitors annually. Experience at such localities as the Soo Locks, Sault Ste. Marie, Michigan, and the locks of the St. Lawrence Seaway shows that canals and locks are popular tourist attractions. Because the location of considered waterway is in a tourist area, it can be expected that the Canal will attract many visitors to public viewing areas.

The demand for recreational boating has risen sharply in recent decades as a direct result of increasing per capita income and leisure time. This trend is expected to continue in future decades and together with increasing population reflects a need for additional recreation facilities to meet the growing demand. The Lake Erie-Lake Ontario Waterway would be an attraction for recreational boaters in the eastern United States. The 38-mile distance between Lake Erie

and Lake Ontario would represent a one-day outing in the form of a round trip cruise or an entire weekend trip by exploring the Great Lake Shoreline in either Lake Erie or Lake Ontario.

A current projection within the Great Lakes Basin Framework Study³ shows that by the year 2000 the projected need for over 1 million boat-days of use will exceed the capacity of existing facilities in the combined Lake Erie and Lake Ontario Basins. The Lake Erie-Lake Ontario Waterway would provide surface waters for an estimated 4-5,000 boats per day at a rate of 5 acres of surface water per boat over the 38-mile length, considering a turn-over rate of two per day. There is some recreational boating use of the existing Niagara River, but the attraction of cruising through navigation locks between the two Great Lakes would attract over 1,000,000 additional boat-use days per year, while meeting much of the need for recreational boating in the Lake Erie and Lake Ontario Basin.

Included in the first cost of the waterway is a \$10,000,000 expenditure for recreation facilities. Part of this amount includes \$2,000,000 for a scenic canal parkway to accommodate the thousands of visitors who would travel this route each year in order to view

³ Appendix 9, Vol. II, Recreation Boating, Great Lakes Framework Study (Draft No. 3).

the canal. Another \$2,000,000 expenditure is for a visitor center and observation area to encourage visitation and increase the enjoyment of tourists. Finally, \$6,000,000 is planned for public recreation facilities, such as hiking-biking corridors, observation areas, fishing areas, picnic-observation areas, camping areas, and access entrance to the surge basins for water-oriented activities. The benefits derived from these expenditures were not evaluated, but would be at least equal to the magnitude of the annual recreation related charges.

The safe harbor area that would be built at the junction of Lake Ontario and the canal would provide a safe entrance for large vessels and also a harbor of refuge for the many recreational craft cruising in the area.

88. Ice Control. The trend in recent years has been to extend the navigation season into middle and late December, and surveys are currently underway to examine the feasibility of controlled season extension into the months of January, February, and March. The philosophy of winter navigation is not elimination of ice nor control of the climatic conditions that cause ice formation, but rather, ice management or control through ice breaking and handling of broken ice flows. In this regard, narrow constrictions such as navigation locks and channels present one of the most critical problems, i.e., the passage of large ships, which together with broken ice flows

completely fill the lock or channel surface, thus impeding the hydraulic conditions necessary in the open channel flows required to facilitate navigation. Although season extension studies are in the preliminary stages, there appears to be considerable latitude in ice management created by the alternative channel in the form of the Lake Erie-Lake Ontario Waterway. The prospect exists for using this canal and the Welland in complement to manage ice flows and facilitate extended season navigation.

89. Maintenance Scheduling. In addition to providing insurance against short and long-term failure of the Welland Canal as a water-borne route between Lake Erie and Lake Ontario, Lake Erie-Lake Ontario Waterway would also allow for efficiencies in maintenance operation scheduling between the two facilities. With the increasing possibility of extended season, navigation, maintenance of navigation facilities, such as locks and approaches, has been a question. Normally, maintenance on the Welland Canal is accomplished during the winter and spring periods when navigation is suspended due to ice conditions. The Lake Erie-Lake Ontario Waterway would facilitate an alternating maintenance operation which could be scheduled throughout the year without disrupting service or requiring a closed period for maintenance purposes.

90. National Efficiency and Regional Development. The benefits reported herein reflect the direct effects of the Lake Erie-Lake Ontario

Waterway in terms of savings to shippers and consumers comparing waterborne movements of commodities with other modes of transportation. This evaluation approach to navigation projects is prescribed in Section 7a of the Transportation Act of 1967 (U. S. 83rd Congress, 2nd Session). Indeed the major impact of the canal would be to provide the facility for handling U. S. waterborne transport demand, which is represented by the projected traffic increase from 63.6 to 115.0 million tons between Lake Erie and Lake Ontario in 1990 and 2040, respectively, at a total savings of over \$90 million annually over the 50-year period. However, even with this large initial impact measured in terms of transportation savings, many other impacts are created, which, although not as readily quantifiable, are nevertheless of considerable importance. Transport cost must be considered together with labor, raw material, and other costs, which go into the decision-making process regarding production and industry location. Regional advantages are gained from low cost transportation with a multiplier effect resulting in the form of increased employment, income, and social well-being in direct proportion to industry production and expansion. The national economy is similarly stimulated as the U. S. competitive position in supplying exports of general cargo, grain, and other bulk commodities is enhanced by economical and efficient transportation links between U. S. and world ports. Thus, a navigation improvement such as the Lake Erie-Lake Ontario Waterway, which impacts upon an area as far west as

Montana, as far south as Missouri and West Virginia, and takes in the entire mid-continent as far east as Pennsylvania and New York, has an economic impact well beyond the tangible effect on the costs and rates of commercial transportation.

91. Power Supply. Not all impacts of the canal are beneficial. The generation of hydro-electric power has long been a major water use in the Lake Erie-Lake Ontario area. The non-consumptive use of water for navigation lockages has a potential drawback in the reduction of flows and velocity for use in power generation in the Niagara River. Water that would be required for lockages on the Lake Erie-Lake Ontario Waterway will cause energy losses to the power authority since they use all the water available in normal situations to produce power. Lost water means lost energy and income. Also a portion of the existing capacity would be wasted. The value of an incremental loss of water to the power authority is that amount they would be willing to pay to get that increment back. The value is based on the value of the energy which a given increment of water would produce plus an amount that would be required to invest in capacity to produce the energy lost by another means. This total value was estimated at \$2,500 per cfs yr. Assuming 24 lockages per day, the 1200-foot locks with an 80-foot lift would require about 3,000 cfs daily during navigation season for operation. By using an intermediate gate in the 1200-foot lock, thereby reducing

its usable capacity to 900 feet, 2,200 cfs would pass through the canal daily during navigation season or 1,650 cfs would pass through the canal on an annual basis. This loss of water for power purposes would be worth approximately \$4,100,000 annually. If the intermediate gate were not used annual losses would be substantially higher. The expenditure for such a gate is incrementally justified in the lock design on a water saved basis.

THE GREAT LAKES ST. LAWRENCE SEAWAY SYSTEM EFFECTS

92. Introduction. The Great Lakes-St. Lawrence Seaway Navigation System includes: (1) the five Great Lakes, (2) the St. Lawrence River, (3) the St. Mary's Canal between Lakes Superior and Huron, (4) the connecting channels between Lakes Huron, St. Clair, and Erie, (5) the navigation locks at Sault Ste. Marie, (6) the Welland Canal including 7 navigation locks, and (7) the St. Lawrence Seaway including 5 navigation locks connecting the Great Lakes with the Atlantic Ocean. In addition, a large number of navigation harbors have been developed and maintained to handle millions of tons of waterborne commerce (a total of 66 individual U. S. harbors handled over 208 million tons in 1972).

93. System Constraints. The ships serving the Great Lakes-St. Lawrence Seaway are designed to system capabilities with major limiting factors represented in the navigation locks at Sault Ste. Marie, the Welland Canal, and the Seaway. Ship sizes vary directly with the controlling

dimensions of the locks. At Sault Ste. Marie, parallel lock facilities exist capable of handling vessels up to 1,000 feet in length and 105 feet in beam. A number of vessels in the 800 to 1,000 foot class are involved in Great Lakes navigation primarily in the movement of iron ore between Lake Superior and Lake Michigan-Lake Erie ports. Traffic interchange between Lake Erie and Lake Ontario is limited by the size of the Welland Canal locks, which have an overall dimension of 800 feet in length by 80 feet in width, accommodating vessels up to 730 feet long and 75 feet wide. Seaway locks are identical to the Welland Canal locks in size and thus, present similar traffic limitations.

A second major constraint to the Great Lakes-St. Lawrence Seaway traffic exists in the form of a period closed to navigation during December, January, February, and March of each year. Because of climatic conditions in the northern regions of North America ice formation has restricted navigation to an 8-1/2-to 9-month operating period in the waters of the Great Lakes and St. Lawrence Seaway.

94. Increased Capacity. As the economies of scale involved in moving large volumes of bulk cargo in single vessel loads has been served by the technology in the construction of large bulk cargo vessels the demand for navigation improvements on the Great Lakes-St. Lawrence Seaway System has increased.

The completion of the Poe Lock at Sault Ste. Marie in 1969 with

overall dimensions of 1,200 feet in length and 110 feet in width is indicative of the need for increasing navigation facilities throughout the system. Ever increasing volumes of iron ore, grain, petroleum, and general cargo have taxed the navigation locks and channels of the system in recent years. Major investments have already been directed to traffic management and control in the Welland Canal-St. Lawrence Seaway portion of the system. These investments have had the effect of adding capacity to the system by extending the economic life of the Welland Canal from the mid-1970's, which was considered to represent the capacity point in earlier U. S. and Canadian traffic studies, to about 1990 which is currently considered as representing the point of traffic capacity at the Welland facilities. Traffic management is acknowledged to have the ability to extend existing facilities to realize maximum practical capacity. Current simulation studies examining the existing and future operations at the Welland Canal establish the limits of traffic control and identification of performance results of a variety of potential improvements. Among the improvements tested were maximum optimization of traffic management, the addition of super 1,200-foot x 110-foot locks in series, and the addition of parallel super locks in alternate facilities. The conclusions reached in this report are: (1) the existing Welland Canal will reach a practical capacity in the 1990 decade even with additional optimization in traffic management, (2) that the replacement of the existing 7 locks (800' x 80') with larger

1,200' x 110' locks in series provides limited short-term (20-30 yrs) traffic capacity, and (3) that a parallel facility with 1,200' x 110' locks together with the existing Welland Canal provides adequate capacity to handle expected traffic demand over the 1990-2040 period.

95. Traffic Demand Effects. In establishing the conditions under which the study of the Lake Erie-Lake Ontario Waterway was constructed, the factor of traffic demand cannot be overly stressed. Traffic demand represents a continuum of cause and effect conditions which depicts an elasticity affected by numerous direct and indirect forces. As indicated above the size of navigation facilities represents a controlling condition which is probably the most important constraint on traffic demand. The question as to whether traffic demand supports transport facilities or whether transport facilities attract new traffic (which may be a diversion from other facilities which become underutilized) is sometimes difficult to quantify.

The traffic projections developed in this study represent an analysis of demand for the movement of bulk and general cargo between Lake Erie and Lake Ontario for which waterborne transportation has a favorable rate differential when compared with other available transport modes. In this context the present navigation facilities represent as a transport system are considered as a base together with the existing competition represented in the facilities of other transport modes.

A major change in the technology and/or capability of waterborne or inland transport modes would be expected to have some impact on overall transport demand. In this regard there are a number of transportation improvement studies now underway that could have an effect on the balance between waterborne and inland competitive advantage and thus impact upon the traffic levels used in the analysis of the LE-LO Waterway. Further any increase in waterborne traffic could have the effect of advancing the capacity point of the existing Welland Canal. The reverse would, of course, have a corollary effect. That is, any change in competitive advantage favoring inland distribution of traffic would likely reduce waterborne demand and have the effect of extending the economic life of existing facilities. This is not to present a qualification of traffic projections in this study, but to suggest that traffic demand should be closely monitored in the analysis and planning phases of transport facilities because of the major impact that an increase or decrease of traffic volume has on the timing, sizing and sequencing of transportation improvements.

96. Effect of Ongoing Studies in the System. In line with the foregoing discussion of transport demand and competitive balance are the potentials for Great Lakes traffic inherent within ongoing studies to determine the engineering and economic feasibility of: (1) extending the navigation season on the Great Lakes and St. Lawrence Seaway; (2) the twinning of navigation locks on the St. Lawrence Seaway, and

(3) lock replacement and channel improvements at Sault Ste. Marie and the St. Marys Canal.

Of the ongoing studies, extending the navigation season on the Great Lakes-St. Lawrence Seaway System presents an, at present, unknown impact on the role or regularity of service in the decision making policy of transport users. Such important aspects as location of industry, expansion of existing facilities, and production and/or consumption increases which together reflect total transport demand may be strongly affected by, in effect, adding a new transport route for up to 30 percent (3-1/2 months) of the calendar year. Should the season extension be accomplished and a catalyst effect occur on Great Lakes-St. Lawrence Seaway traffic demand the projections represented in this study could emerge as conservative. On the other hand, a reverse effect could occur given a combination of existing traffic demand (as represented in this study) together with an extended shipping season which could have the result of increasing system capacity by extending what is now a 9-month transit rate over 10, 11, or 12-months, thus, spreading traffic over a longer shipping season and reducing peak loads which are normally experienced in November and April at the close and opening of navigation.

97. Policy Decision Effects on Commodity Movements. In addition to the effect of transportation improvements on the competitive balance among transport modes are the potential changes in the demand for

movement of commodities as affected by: (1) source of availability of commodities, (2) environmental policy affecting commodities and (3) governmental policy covering import and export practices.

Distance between producing areas has an important effect on waterborne transport demand. Iron ore production in the Mesabi Range of Minnesota is a prime example of a near captive source of waterborne traffic from Lake Superior to points throughout the Great Lakes-St. Lawrence Seaway System. Grain and coal involve inland distribution to port facilities for longer haul delivery to consuming points which may be located directly on water sites or require further inland distribution beyond the port of destination. Thus, the shift in origin-destination of consuming or producing points can have a direct effect on the waterborne advantage over inland transport modes. To the extent foreseeable such shifts have been taken into consideration in the traffic forecasts developed in this survey.

Even more difficult to determine over a projection period covering 50 years or more is the relative weights given to developmental programs stressing economic expansion and exploitation of available resources vis a vis the consideration of environmental impacts and preservation goals as they are adversely affected by the developmental and expansion processes. This tradeoff may be seen in the current role of coal in providing energy in what has become an energy source economy.

Environmental goals, regarding land, have resulted in higher production costs of coal and environmental restrictions, regarding air pollution, have resulted in large cutbacks in the use of high sulphur coal in the electric power industry. Projections of waterborne transportation of coal developed in this study of the Lake Erie-Lake Ontario Waterway are based on the current environmental policy which presents major constraints on the use of coal produced in the Great Lakes tributary area. Hence, coal demand is depicted as reflecting only a peaking source of power supply in future decades, rather than a major source that was the case in past decades. Should environmental policy shift or technology develop devices to reduce the environmental impact of combustion of fossil fuel in the generation of electricity, coal traffic between Lake Erie and Lake Ontario could exceed the projections by a large margin.

Government policy on imports and exports together with the U. S. competitive position in the supply and demand conditions of foreign markets is the major variable in the existing waterborne movement of grain and general cargo between Lake Erie and Lake Ontario. Added to these commodity groups, concerned with government trade policy is petroleum in future decades, when increasingly large volumes of crude oil are expected to be imported from foreign sources. Petroleum supply and distribution is a major topic at present, and national energy policy has not emerged on a long-range basis. Should

crude petroleum be imported at the rate projected in recent studies, which shows up to a billion tons being imported by 2000, distribution to interior consuming areas could tax pipelines to the point where the Great Lakes-St. Lawrence Seaway System would become a major transport artery. The current projection of just over 2 million tons of petroleum between Lake Erie and Lake Ontario in 2040 could be increased by 10-fold or more in distributing a billion tons of crude or refined product. The present consensus is that the Great Lakes will not share in the transport and distribution of petroleum and that consensus is represented in the projection of petroleum in this study.

98. Findings of the Economic Studies.

1. Using presently definable economic, environmental, and governmental policy conditions as a basis, U. S. traffic between Lake Erie and Lake Ontario will increase from 43.3 million tons in 1971 to 63.6 million tons in 1990 and 115.0 million in 2040.

2. Traffic demand, the major variable in the determination of capacity of existing navigation facilities, is subject to change between the present and 1990 as a result of one or more of the following: the impact of technology and total U. S. transport system improvements on the competitive advantage of individual transport modes; source and availability of bulk and general cargo commodities; environmental policy and; governmental policy.

3. Based on present origin-destination traffic patterns, the average savings for waterborne movement on the Great Lakes-St. Lawrence Seaway System over alternative modes is \$7.27 per ton.

4. Simulation of existing navigation facilities between Lake Erie and Lake Ontario reveals that:

a. the Welland Canal will reach practical capacity about 1990 under current policy and assumptions regarding future traffic and fleet composition;

b. to provide adequate capacity for a 50-year period from 1990-2040 parallel facilities will be required; and

c. a canal between Lake Erie and Lake Ontario, via the Niagara River, of either 4, 5, or 6 locks each 1,200' x 110' together with the existing Welland Canal will provide adequate capacity through the 1990-2040 study period.

5. Benefits from transportation savings in the form of rate differentials between waterborne and alternative modes for traffic between Lake Erie and Lake Ontario attributable to the additional capacity provided by the LE-LO Waterway represents a total of \$91.2 million annually from 1990-2040 discounted at 5-5/8 percent; and when netted out from benefits attributable to the St. Lawrence Seaway, result in a net transport savings of \$70.3 million assignable to the considered LE-LO Waterway improvement.

6. Additional savings from reduction in traffic delay for the 63.6 million tons of existing traffic in 1990, not limited by capacity of the Welland Canal, amount to an average annual savings of \$6.2 million.

7. A number of secondary impacts occur from the Niagara Canal including: (1) an annual saving of over \$20 million to the Canadian economy, (2) insurance against partial or total failure of the Welland Canal in providing transport facilities between Lake Erie and Lake Ontario, (3) recreation benefits, (4) ice control in winter navigation, (5) efficiency in maintenance scheduling, (6) national efficiency and regional development impacts, and (7) a potential adverse impact on the reduction of water supply for power generation in the Niagara River vicinity.

8. Net primary benefits related to transportation savings total \$76.5 million, combining rate savings of \$70.3 million and reduced operating costs (delay reduction) of \$6.2 million.

9. Average annual charges for providing the Niagara Canal over a 38-mile channel with five navigation locks each 1,200' x 110' is \$176.1 million amortized over 50 years at 5-5/8 percent interest.

10. The benefit/cost ratio using average annual transportation savings as a measure of benefits compared with average annual costs is 0.4/1.00.

99. LOCAL COOPERATION AND ALLOCATION OF COST

Local cooperation, in terms of sharing in the financing, is not required for the new waterway. As an improvement of navigation, all costs of construction are a Federal responsibility. Local civic, commercial, and political entities have an interest in the outcome of the study. In fact, such groups were original proponents of the waterway, and a moving force behind securing study authorization.

The New York State Joint Legislative Committee on Commerce and Economic Development held public meetings in 1960 and 1965, with generally favorable comment. In addition, the Corps of Engineers has held a series of public information meetings, workshops, and final public meetings in localities along the proposed waterway route. In general, business interests projected a favorable view in terms of increased commerce, both locally and throughout the system. Local civic officials and citizens expressed concern over the new waterway, effects on the adjacent political and social environment, although many objections were to the siting of the route and not to the concept or need of a waterway.

COORDINATION WITH OTHER AGENCIES

100. Introduction. During the course of the study, many contacts were made with a variety of agencies. The purposes were to advise the agencies of the study and of the plan being considered, to obtain basic data for use in the study, to obtain information on plans and programs of the agencies, and to determine and attempt to resolve

any conflicts. The contacts are outlined below.

101. Federal Agencies. The Department of Transportation cooperated in the origin-destination study for the economic analysis. The Coast Guard furnished information on aids to navigation and effect on Coast Guard operations. The St. Lawrence Seaway Development Corporation furnished information on traffic and lock operations for the United States locks on the St. Lawrence Seaway, for use in the economic analysis. The Fish and Wildlife Service furnished views on impact of the project upon fish and wildlife resources, and also ideas for development of facilities for recreational fishing.

Other Federal agencies were also consulted. They furnished comments, especially on environmental effects. These agencies were Bureau of Outdoor Recreation, Federal Highway Administration, Geological Survey, Federal Aviation Administration, National Park Service, Soil Conservation Service, Forest Service, and the Environmental Protection Agency.

102. State Agencies. The Department of Transportation furnished information on highway traffic and future highway plans along the overland portion of the route. The Department of Environmental Conservation furnished its views on development of recreational facilities, impact on fish and wildlife, and surface and ground water resources. The Office of Parks and Recreation furnished its views on development of recreational facilities.

103. Local Agencies. Erie and Niagara Counties Regional Planning Board furnished data on long range plans for the development of the area. It also furnished data on existing and projected conditions; especially socio-economic data for the two-county area. Other county agencies furnished comments on various matters related to their individual areas of concern, and on environmental aspects. Local governments furnished information on assessed valuations of properties along the route and on possible impacts upon local governments.

FINAL PUBLIC MEETINGS

104. Introduction. Two final public meetings were held in September 1973. The purpose was to present a review of the study and its draft conclusions and recommendations so public comments could be incorporated and final conclusions and recommendations could be developed.

Invitations and copies of the draft of the Summary Report were mailed to more than 500 local citizens and almost 3,000 persons representing governmental, commercial, and other interests throughout the Great Lakes System. In addition, environmental and conservation organizations were sent this information and news releases were sent to all media. Full sets of the draft report were sent to local libraries and Corps of Engineer Offices along the Great Lakes. The Draft Summary Report invited review of the report at those locations.

105. Wheatfield Public Meeting. The first meeting was held during the evening of 25 September 1973 in the town of Wheatfield, Niagara County, NY. This meeting allowed citizens to again voice their major concerns with a waterway passing through their localities. Approximately 150 persons attended the meeting. The District Engineer, Buffalo District, presided.

Several Mayors and other political representatives spoke. The Mayor of the city of Niagara Falls continued to favor the development of advanced transportation systems in the region. He emphasized the benefits of national security and pride and benefits to the local and regional economy. The Mayor also suggested a look at building a large harbor on Lake Ontario even if the canal was not feasible. The Mayor of North Tonawanda stressed that quality of life should be as important as development and questioned the secondary benefits to the area. He had many contacts with residents, many of whom were concerned with the path of the waterway and the relocation of facilities, especially a railroad. The Supervisor of the town of Wheatfield strongly disputed the study's mention of potential regional economic gain. He referred to an earlier large-scale project that had held out the promise of jobs and development, but had not, in fact, had a satisfactory impact on the area. A study for a regional jetport is also considering a Wheatfield site, and the Mayor stated that he and his constituents preferred to do without such outside interference. The town of Lewiston had adopted a

resolution in opposition to the canal because of its disruption of services and cutting part of the township off from the rest.

Other individuals at the meeting stressed their displeasure with the change in their lifestyle, especially farming, that the waterway would entail. An historical society representative was particularly concerned with the old German-culture village of Bergholtz, which has retained much of its original character. He was opposed to the alignment being considered because it passed so close to the community and would therefore have a disruptive influence. Some individuals spoke in favor of the concept and general plan of an All-American Canal for both the national good and regional benefits. Others were anxious to find out the legal and financial implications of property acquisition and relocation because they lived on or near the proposed alignment. While there were no strong objections to the recommendations, there was desire expressed by some to spend no more money to study a waterway. The transcript and statements of that meeting are contained in a supplement to this Main Report.

106. Chicago Public Meeting. The second public meeting was held during the afternoon of 27 September 1973 in Chicago, Il.. This meeting allowed shippers, agencies, and others interested in the waterway and system as a whole to respond to the draft report. Approximately 50 persons attended the meeting, which was presided over by the Deputy District Engineer, Buffalo District.

Several agency, industry, and organization representatives attended the meeting, but very few comments were made. The Seaway Development Corporation, a quasi-governmental organization, had several negative comments. The representative believed that national security was not adequately considered. He also believed that balance of payments and additional economic benefits should be considered. His other comments centered around the question of who should carry out the United States portion of any future studies. He felt that the U. S. Department of Transportation had not been properly coordinated with in the later stages of the study and that the Department of Transportation should be the principal agency involved in any subsequent cooperative efforts.

A representative of the Industrial Users of the Great Lakes urged quick and thorough study of the total system so that commerce can be continued in the future with no constraints. He felt that there are additional economic advantages, including the avoidance of lost business, that should be included in future studies, and that those studies be combined with others, such as the Extension of the Navigation Season. Lastly, he pointed out that, based on an industrial survey, alternative modes of transportation are not available for many industries. Therefore, the economic benefits of any waterway improvements would be greater.

The organization of Navigation Pilots representative urged

cooperation with Canada for any U. S. or Canadian plan considered. He believed that the good will with Canada was necessary for continued open overseas trade and to keep our international waterways, such as the Panama Canal, open to U. S. traffic. he also supported improvements to existing facilities and any future expansion needed.

The State of Ohio Department of Natural Resources sent a telegram concurring with the recommendations of the Buffalo District regarding an international approach to the Waterway System.

The transcripts and statements of the meeting are contained in a supplement to this Main Report.

107. CONCLUSIONS

1. Some major waterway improvement, in the form of a new waterway or structural improvement to the Welland Canal locks and channels, must be constructed between 1980 and 1990 to prevent the restriction of navigation between Lake Erie and Lake Ontario. This restriction would have an adverse effect on the economic benefits that would otherwise develop with the natural growth of waterborne transportation in the Great Lakes Area.

2. A decision on what form of structural improvement should be undertaken must be made by 1980 in order to allow adequate construction time between 1980 and 1990.

3. The benefit/cost ratio for the proposed plan is 0.4 to 1, compared to 1.48 to 1 for the plan developed in the 1961 Feasibility

Report. The proposed plan is more comprehensive than the previous plan, which accounts for some of this change. Escalation of prices, however, and the increase in the interest rate from 2-5/8 percent to 5-5/8 percent, are responsible for the major portion of this drastic reversal. As the interest rate increases, benefits decrease and costs increase.

4. A new canal would provide adequate capacity for 50 years and substantial benefits in transportation savings plus numerous other secondary benefits.

5. If the Lake Erie-Lake Ontario Waterway were provided, regional development would be stimulated and recreational opportunities in the area would increase. Our studies have concluded that the Lake Erie-Lake Ontario Waterway is technically and ecologically feasible, but not economically justified based solely on transportation savings and when analyzed as an increment to, rather than an integral part of, a system.

108. RECOMMENDATIONS

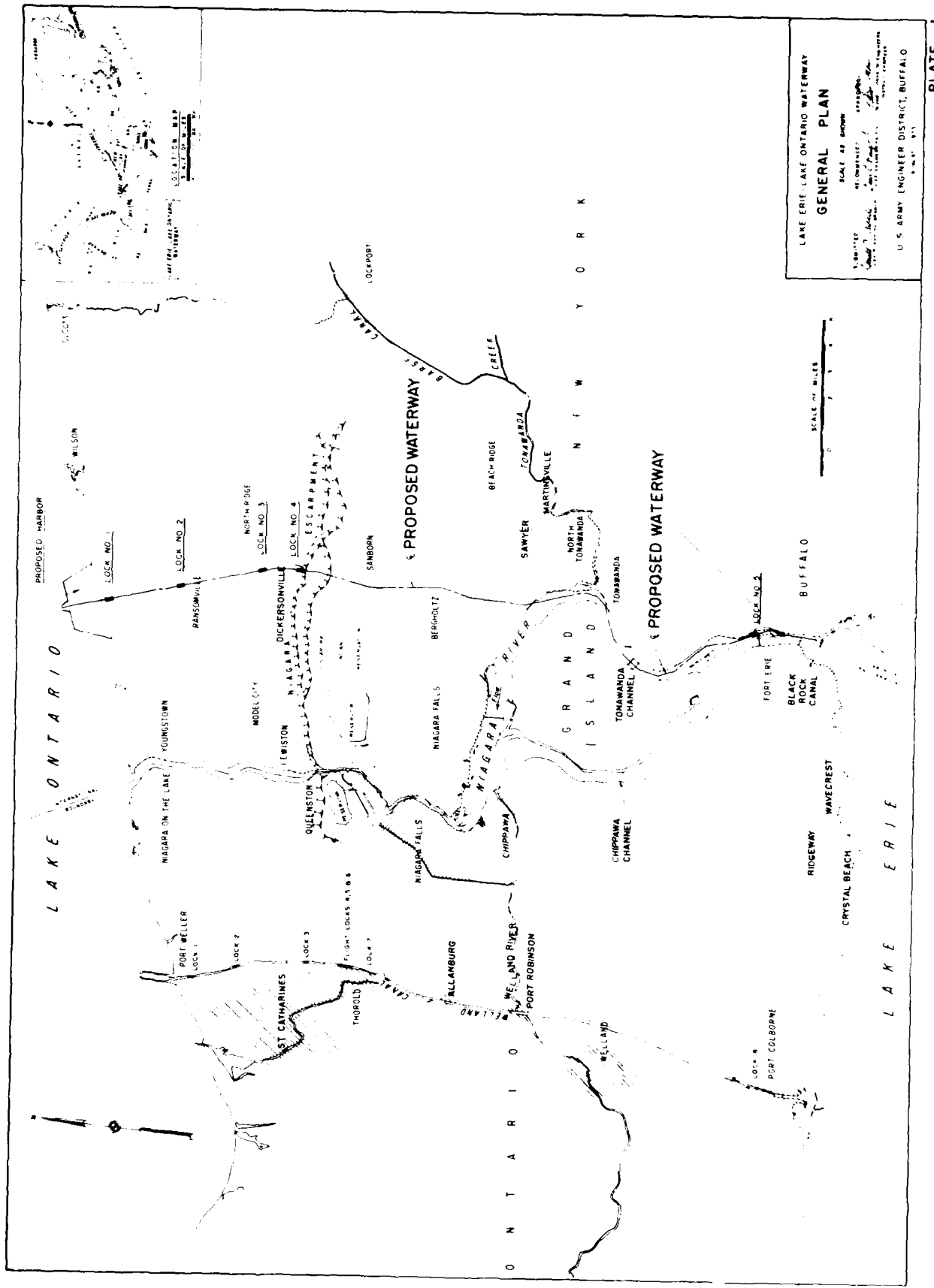
1. There should be international cooperation to consider existing conditions and future needs of the total Great Lakes-St. Lawrence Seaway Navigation System. Studies to date indicate a need for major structural improvements by about 1990, between Lake Erie and Lake Ontario, in order to prevent future constraints to the Navigation System.

2. The cooperative effort should be undertaken immediately in order to reach decisions by 1980 that should allow physical facilities to be developed before navigation capacity is met.

3. Such an effort should consider the total demand for transportation in the United States and Canadian Great Lakes-St. Lawrence Region, with a goal to meet these countries' needs in 1990 and subsequent decades.








4. Advantage should be taken of ongoing navigation studies, such as the Great Lakes Navigation Season Extension Study and the St. Lawrence Seaway Study for relevant data and conclusions.

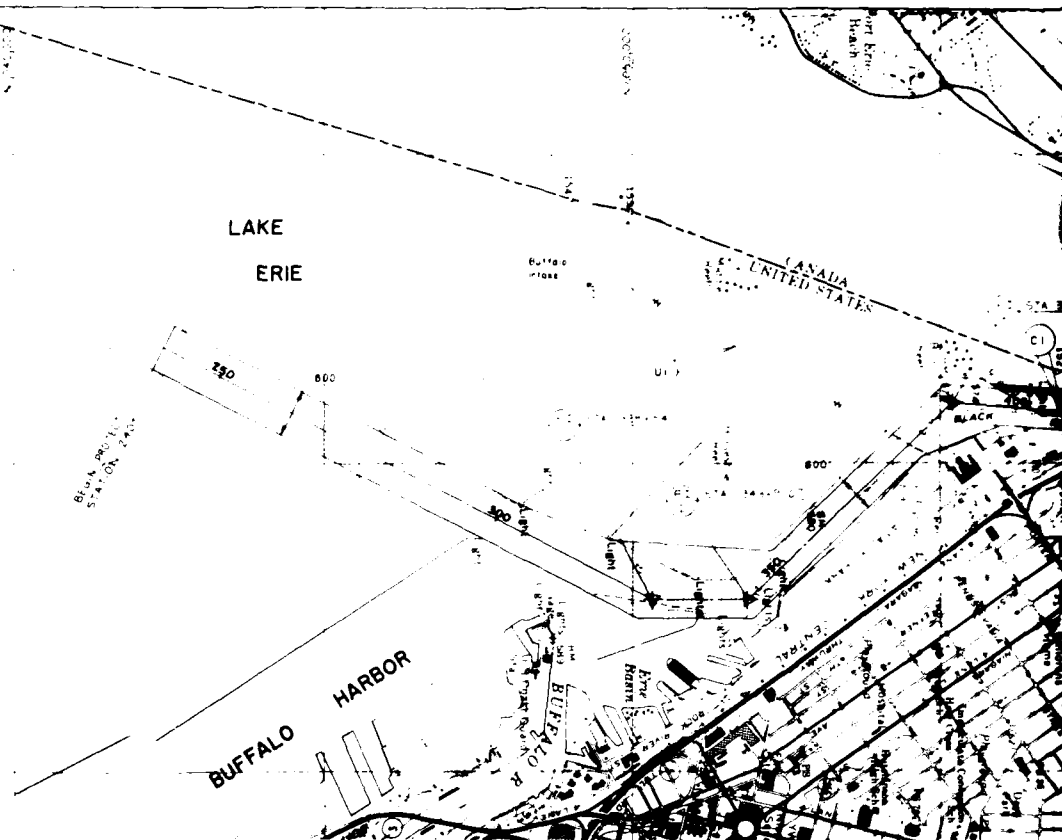
5. The major goal of the cooperative effort should be to develop a system-wide program for the Great Lakes-St. Lawrence Seaway Navigation System to insure proper timing, sizing, and sequencing of future navigation improvements to agree with the projected need.



LAKE ERIE-LAKE ONTARIO WATERWAY
GENERAL PLAN
 SCALE AS SHOWN
 U.S. ARMY ENGINEER DISTRICT, BUFFALO
 1911

LEGEND

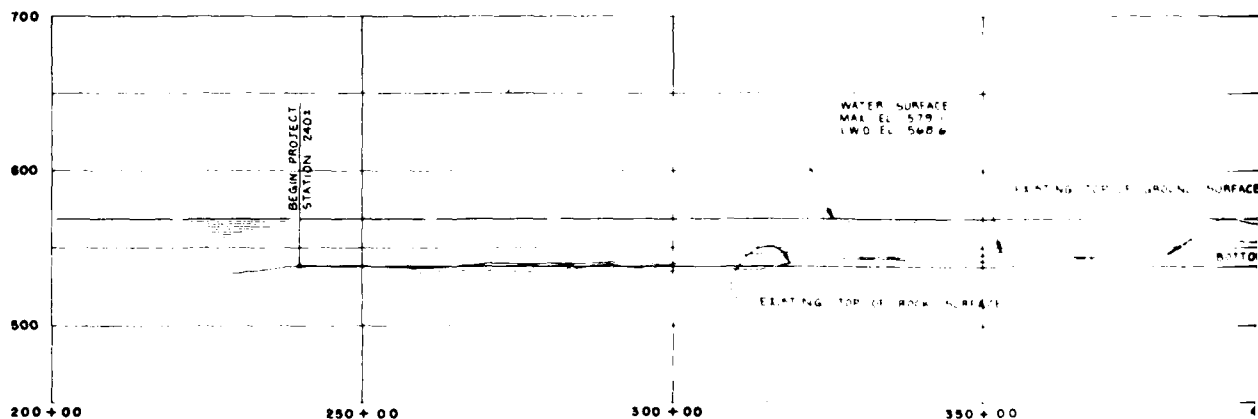
-  SURFACE AREA OF CHANNEL, CANAL, OR HARBOR WITH CLEARANCE TO PROJECT DEPTH
-  RELOCATED RAILROAD, HIGHWAY, OR UTILITY NOT DEFINED BY EMBANKMENT OR EXCAVATION
-  EMBANKMENT AREA
-  EXCAVATION AREA (SHOWN FOR OVERLAND SECTION ONLY)
-  SURGE AREA FOR LOCK OPERATION
-  DRAINAGE RELOCATION
-  INDICATION OF A SPECIFIC ITEM OF WORK REQUIRED FOR CONSTRUCTION OF THE WATERWAY



PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000



UTILITIES

- (U1) WATER INTAKE TO REMAIN NO ALTERATIONS REQUIRED
- (U2) REPLACEMENT OF CITY OF BUFFALO AUXILIARY WATER INTAKE TUNNEL WITH NEW TUNNEL AT REQUIRED DEPTH
- (U3) NIAGARA MOHAWK POWER CO. AERIAL CROSSING TO REMAIN NO ALTERATIONS REQUIRED
- (U4) RELOCATION OF NEW YORK STATE DEPARTMENT OF HEALTH GAGING AND SAMPLING STATION
- (U5) ABANDONMENT AND REMOVAL OF NEW YORK TELEPHONE CABLE TO BUFFALO SEWAGE TREATMENT PLANT

- (U6) ABANDONMENT AND REMOVAL OF NEW INVERTER SIPHON TO BUFFALO SEWAGE TREATMENT PLANT
- (U7) REMOVAL OF BUFFALO SEWAGE TREATMENT PLANT FROM SQUAW ISLAND

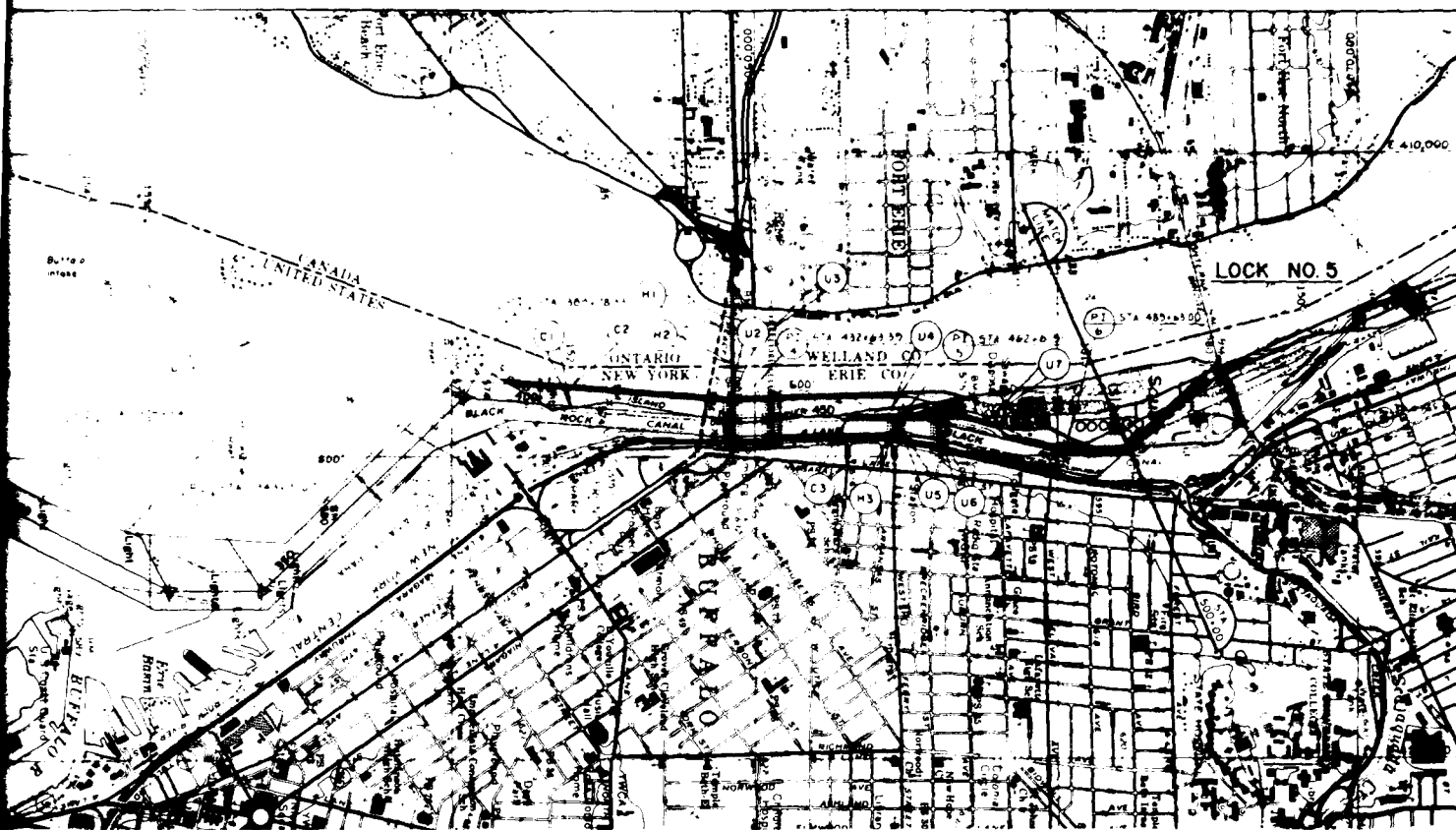
HIGHWAYS

- (H1) REMOVAL OF PEACE BRIDGE
- (H2) NEW PEACE BRIDGE
- (H3) REMOVAL OF FERRY STREET BRIDGE

PROFILE

CHAM

- (C1) REMOVAL OF CHAM
- (C2) REMOVAL OF CHAM
- (C3) REMOVAL OF CHAM



PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000

WATER SURFACE
MAX. EL. 579.1
LOW EL. 568.6

EXISTING TOP OF GROUND SURFACE

BOTTOM OF CANAL EL. 558.6

EXISTING TOP OF ROCK SURFACE

TOP OF WALL EL. 580.0

350+00

400+00

450+00

500+00

PROFILE

CHANNEL IMPROVEMENTS

- (C1) REMOVAL OF PORTION OF BIRD ISLAND PIER LOCATED INSIDE CHANNEL LIMITS
- (C2) NEW BIRD ISLAND PIER WITH ACCOMPANYING DREDGING IN NIAGARA RIVER TO COMPENSATE FOR LOSS OF CROSS SECTION AREA
- (C3) REMOVAL OF SHEET PILE RETAINING WALLS AROUND PORTION OF SQUAM ISLAND LOCATED INSIDE CHANNEL LIMITS

LAKE ERIE-LAKE ONTARIO WATERWAY

PLAN AND PROFILE

STA. 240+00 to 500+00

SCALE AS SHOWN

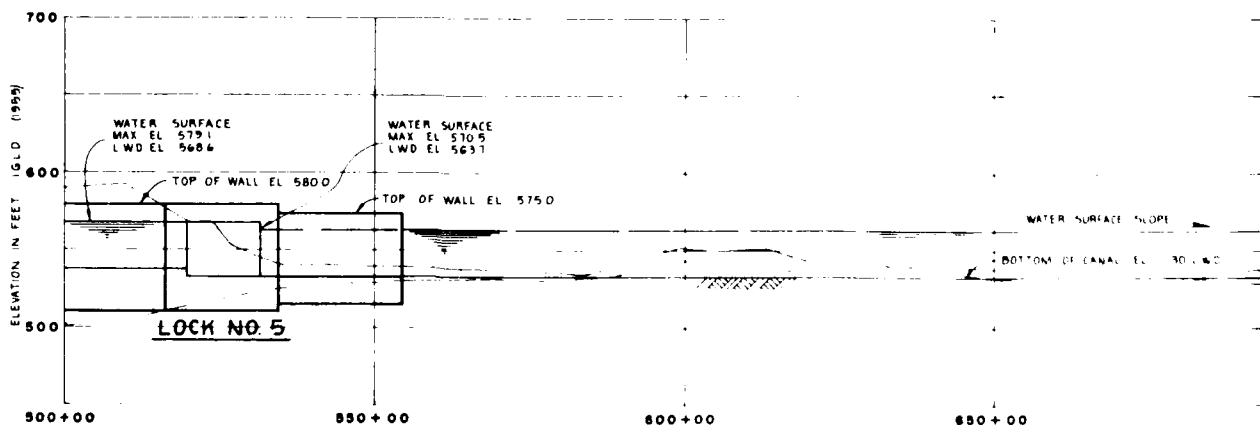
U. S. ARMY ENGINEER DISTRICT, BUFFALO



PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000



UTILITIES

- (U8) REPLACEMENT OF PENN CENTRAL RAILROAD COMMUNICATION LINES WITH LINES OUTSIDE CHANNEL LIMITS (PORTION THROUGH LOCK NO. 5)
- (U9) RELOCATION OF BUFFALO INCINERATOR FLYASH LAGOONS
- (U10) REMOVAL OF ABANDONED INDIAN GAS CORPORATION LINE INSIDE CHANNEL LIMITS
- (U11) WATER INTAKE TO REMAIN NO ALTERATIONS REQUIRED
- (U12) REPLACEMENT OF NEW YORK TELEPHONE CO. SUBMARINE CABLE WITH NEW CABLE AT REQUIRED DEPTH

HIGHWAYS

- (H4) RELOCATED ACCESS HIGHWAY TO PORTION OF SQUAW ISLAND ON NEW BASCULE RAILROAD BRIDGE
- (H5) NEW ACCESS ROAD TO LOCK NO. 5

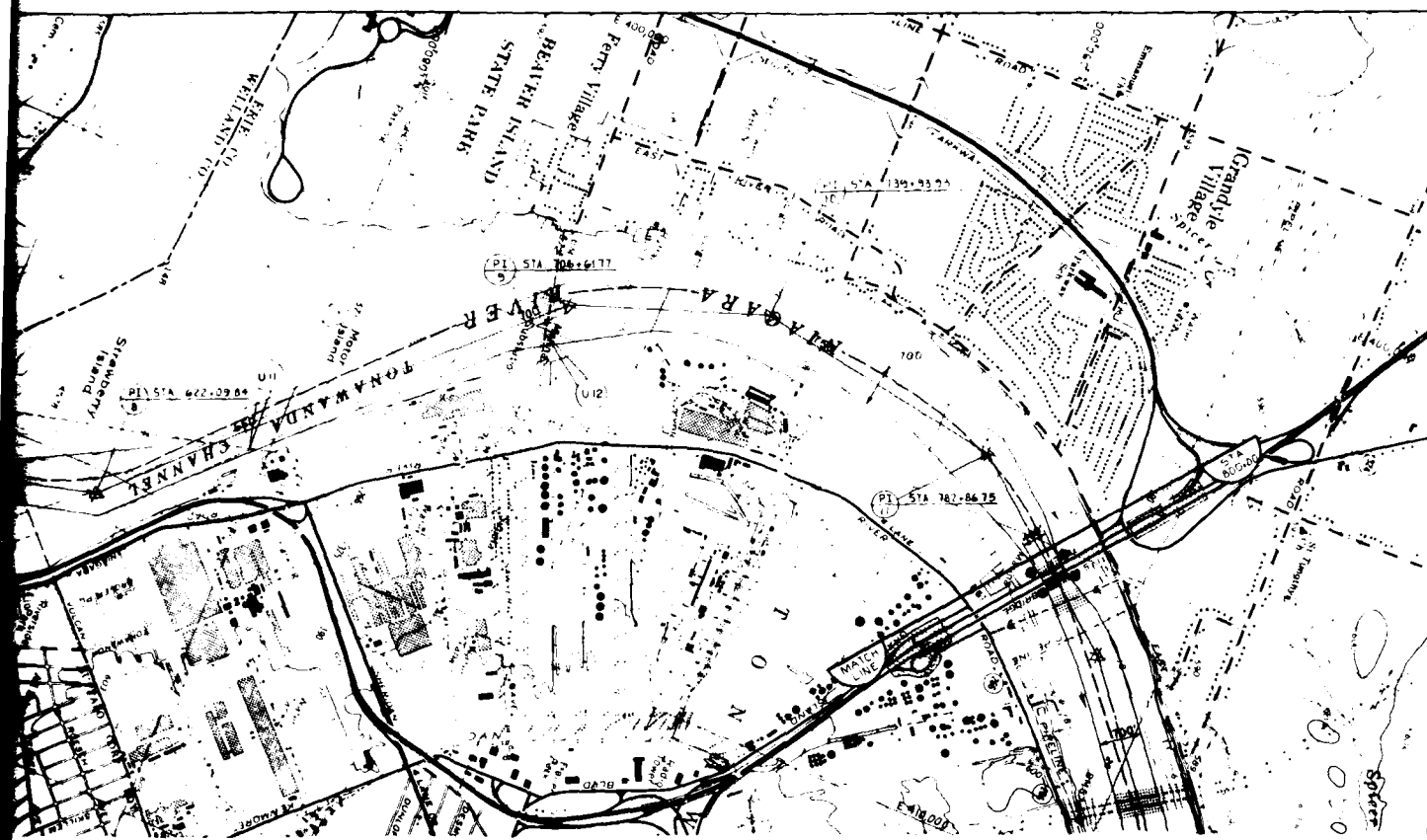
RAILROADS

- (R1) NEW BASCULE RAILROAD BRIDGE LOCATED ON WALLS OF LOCK NO. 5

CHAN

- C4 INSTALLATION
- C5 REMOVAL OF INSIDE CHAN

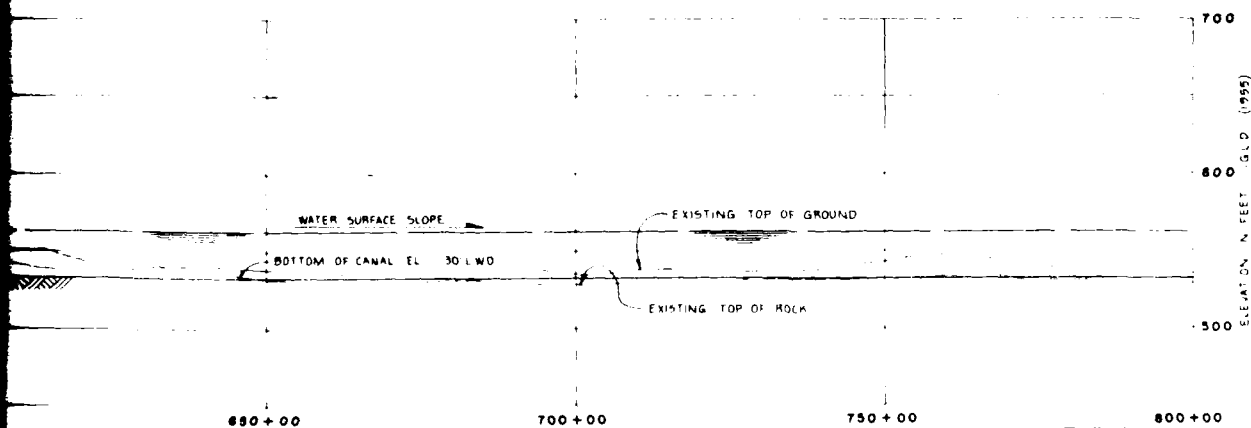
PROFILE



PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000



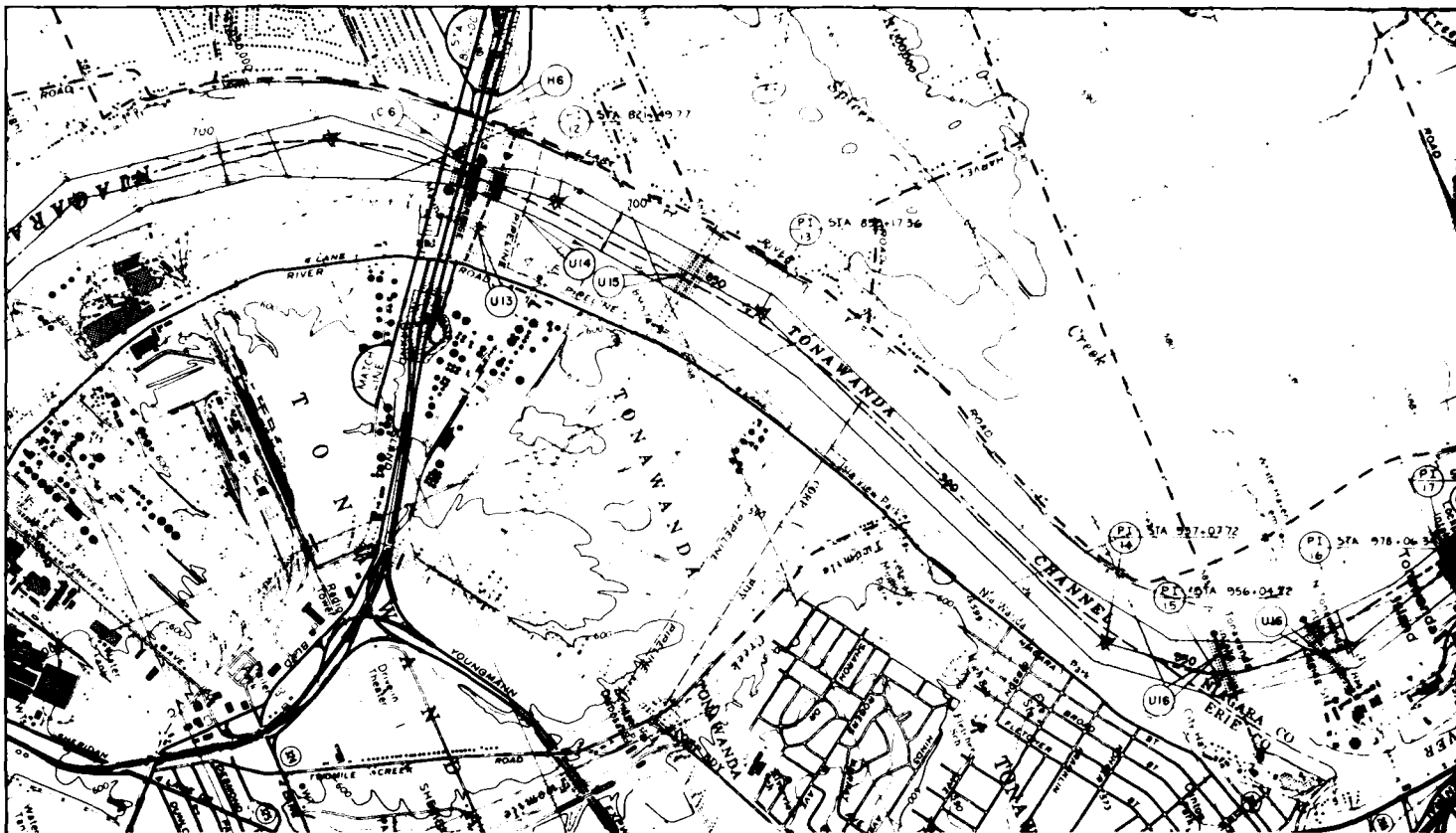
PROFILE

- CHANNEL IMPROVEMENTS
- (C4) INSTALLATION OF SHEET PILE RETAINING WALL
 - (C5) REMOVAL OF PORTION OF BLACK ROCK LOOK LOCATED INSIDE CHANNEL LIMITS

LAKE ERIE-LAKE ONTARIO WATERWAY
PLAN AND PROFILE
STA. 500+00 to 800+00

SCALE AS SHOWN

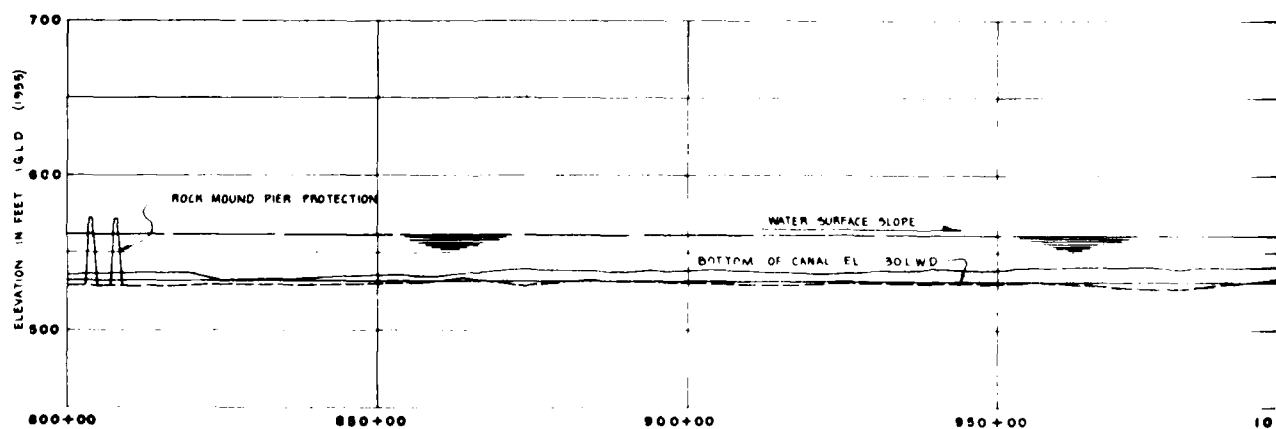
U. S. ARMY ENGINEER DISTRICT, BUFFALO



PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000



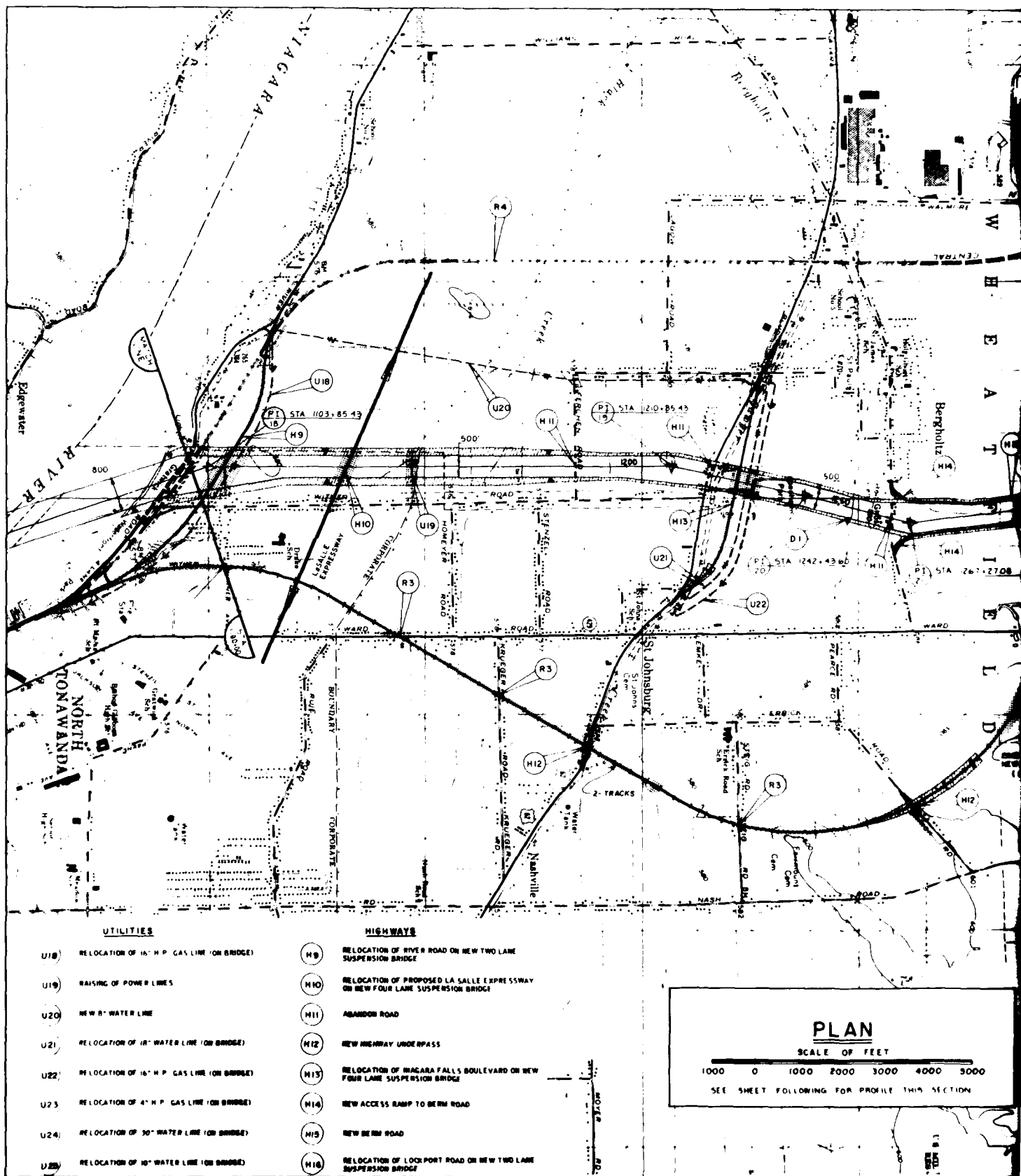
- UTILITIES**
- (U13) REPLACEMENT OF WOODRUM GAS LINE WITH NEW LINE AT REQUIRED DEPTH.
 - (U14) LAKEHEAD PIPE LINE CO. CROSSING TO REMAIN. NO ALTERATIONS REQUIRED.
 - (U15) RAISING OF NIAGARA MOHAWK POWER CO. OVERHEAD LINES AND REPLACEMENT OF SUBMARINE CABLES WITH NEW CABLES AT REQUIRED DEPTH.
 - (U16) REPLACEMENT OF WATER INTAKE WITH NEW INTAKE CHIM LOCATED OUTSIDE CHANNEL LIMITS AND NEW INTAKE PIPE AT REQUIRED DEPTH.
 - (U17) REPLACEMENT OF WATER INTAKE PIPE WITH NEW PIPE AT REQUIRED DEPTH.

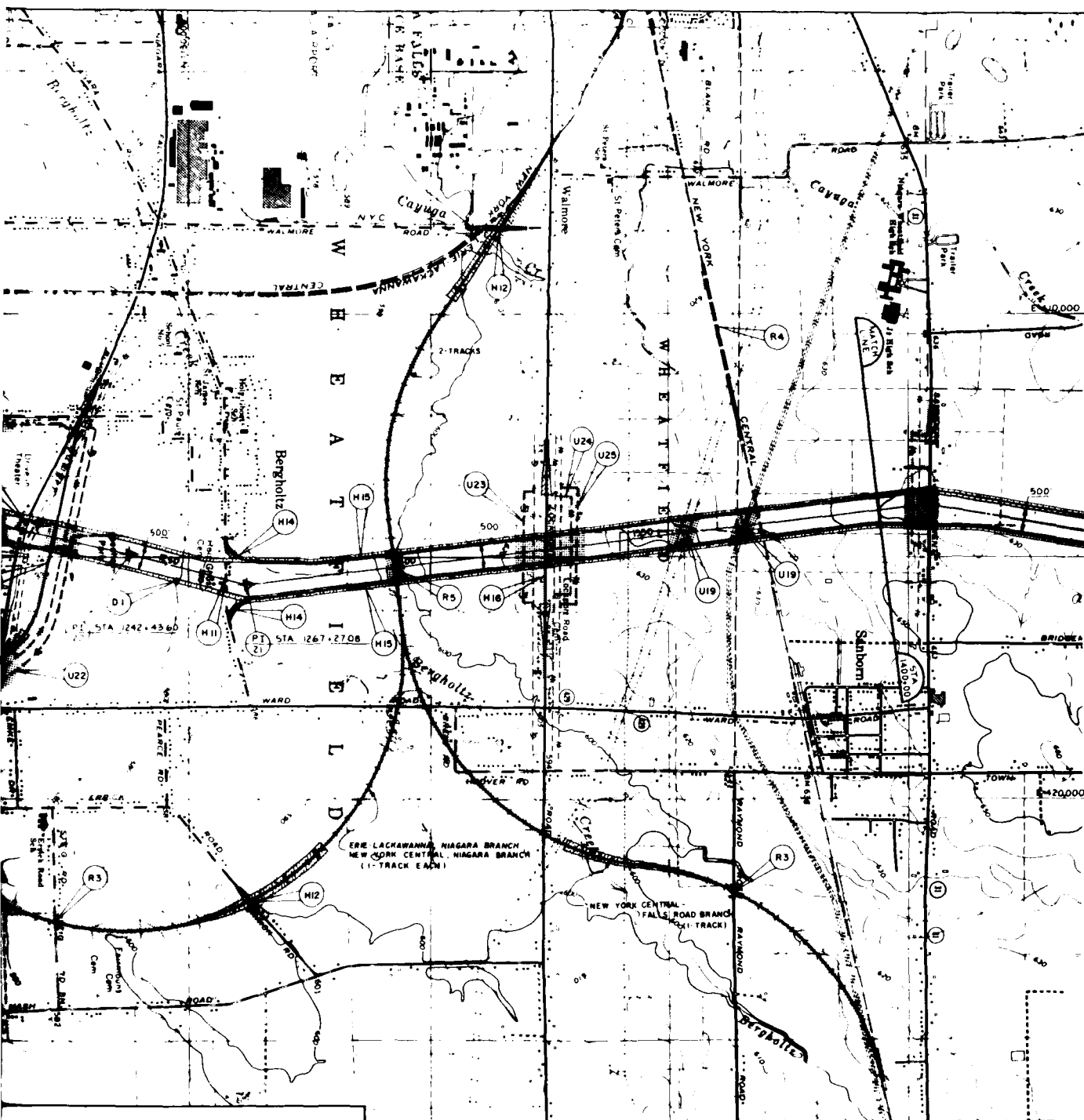
- HIGHWAYS**
- (H6) RAISING OF SOUTH GRAND ISLAND BRIDGES AND APPROACHES.
 - (H7) ABANDON ROAD.
 - (H8) NEW WINTER ROAD - RIVER ROAD CONNECTION.

- RAILROADS**
- (R2) NEW RAILROAD GRADE CROSSING.

PROFILE

(C8) NEW ROCK IN GRAND ISLAND





PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000

SEE SHEET FOLLOWING FOR PROFILE THIS SECTION

RAILROADS

- (R3) NEW RAILROAD GRADE CROSSING
- (R4) ABANDONMENT AND REMOVAL OF EXISTING RAILROAD TRACK
- (R5) RELOCATION OF ERIE LACKAWANNA AND NEW YORK CENTRAL RAILROADS ON TWO PARALLEL SINGLE TRACK CANTILEVER TRUSS SPANS

DRAINAGE

- (D1) NEW BERGHOLTZ CREEK DROP STRUCTURE

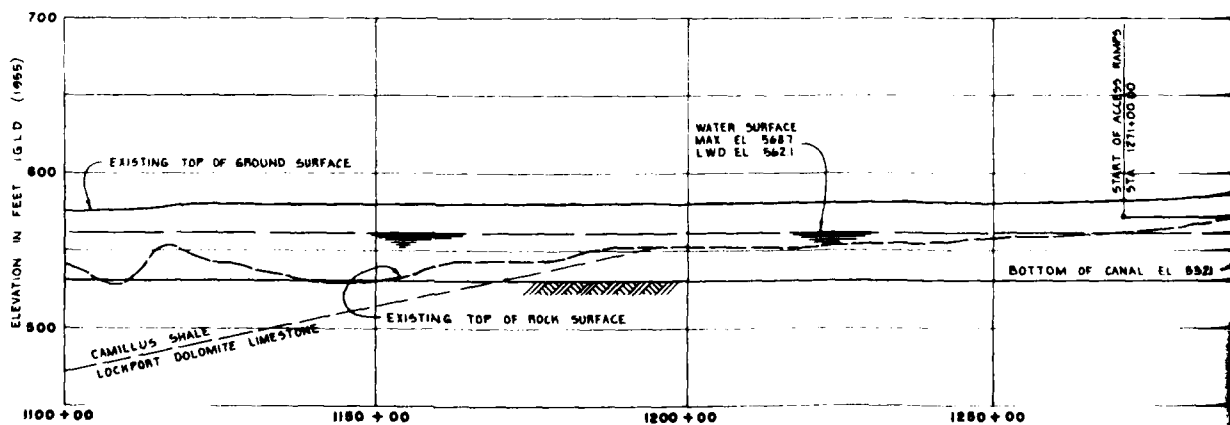
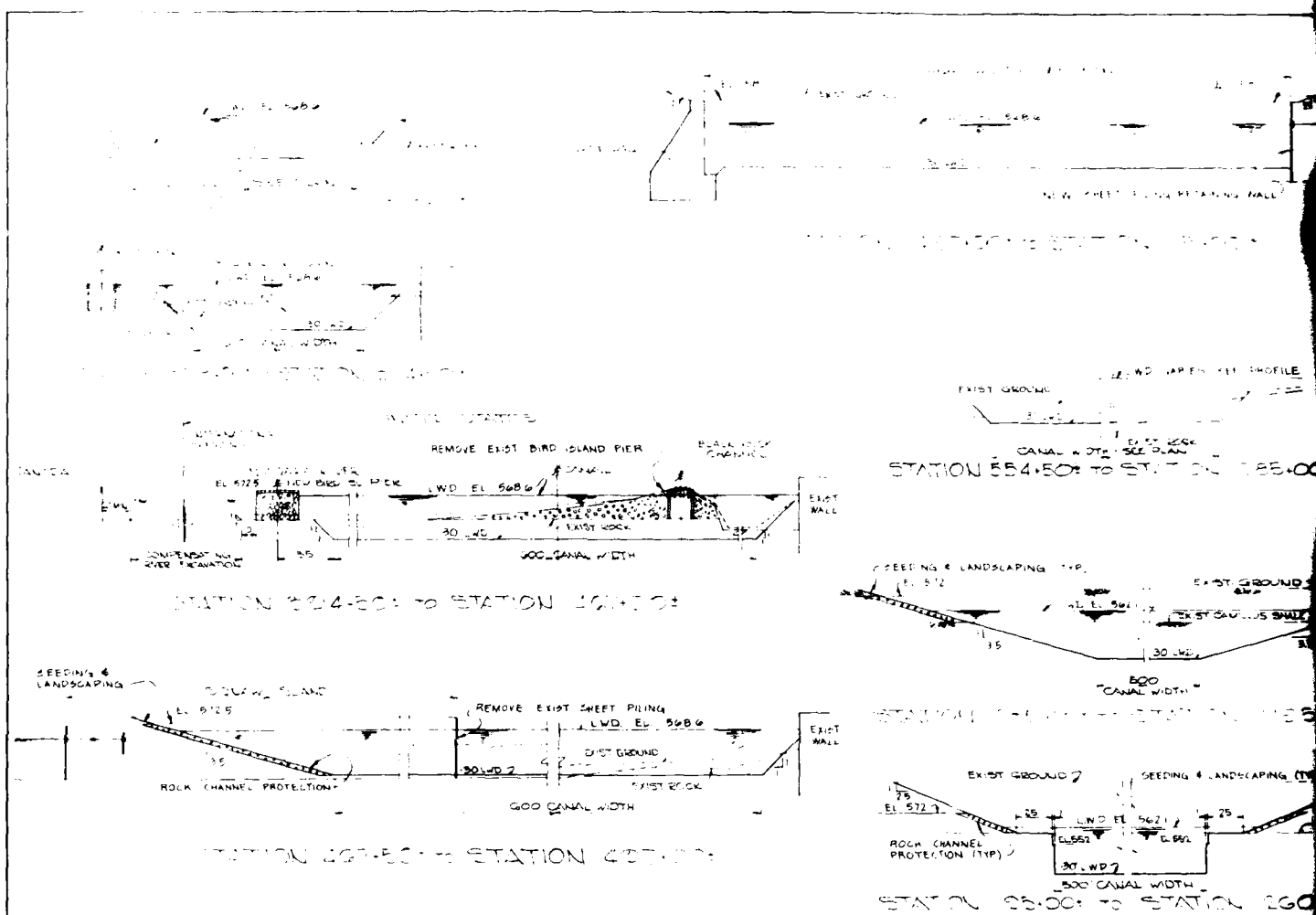
LAKE ERIE-LAKE ONTARIO WATERWAY

PLAN

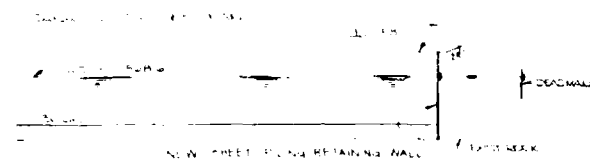
STA. 1100+00 to 1400+00

SCALE AS SHOWN

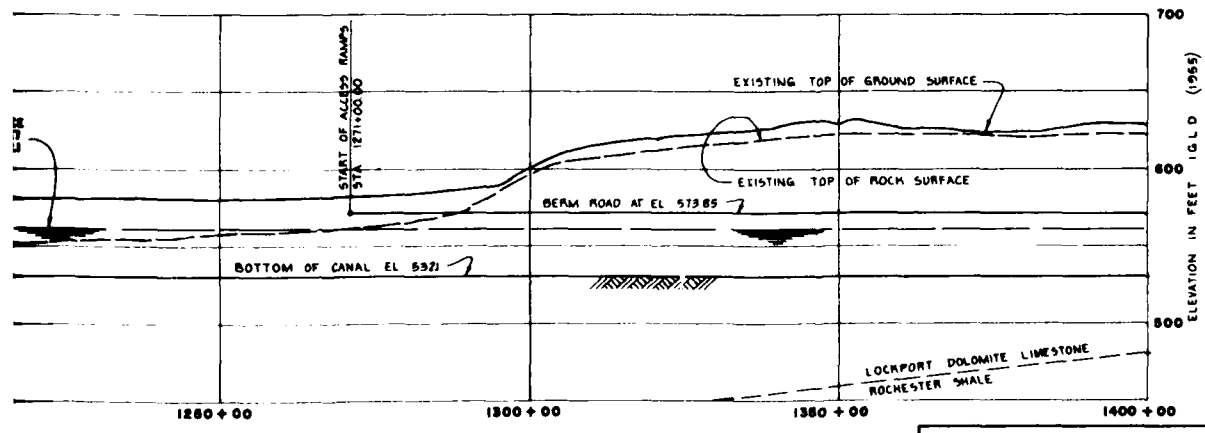
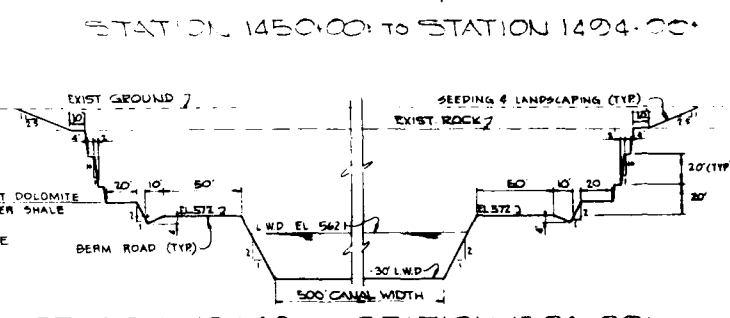
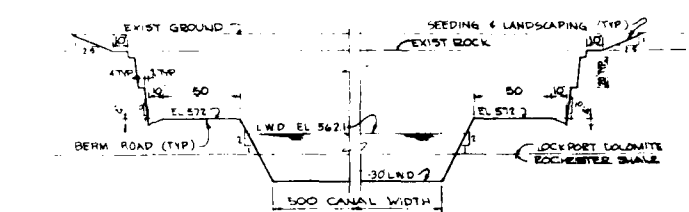
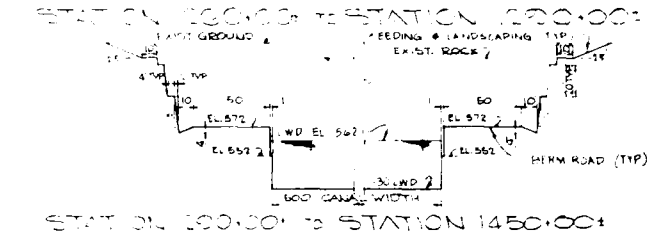
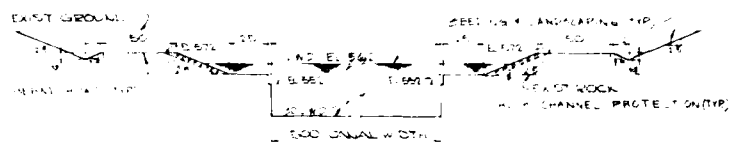
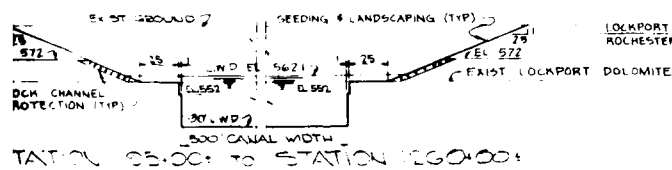
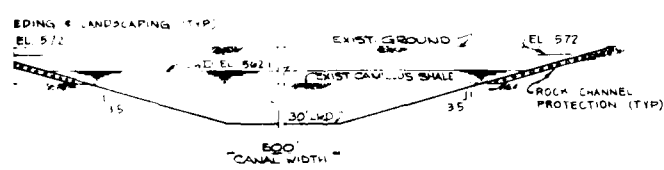
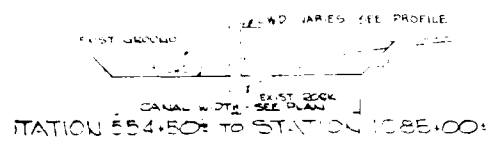
U. S. ARMY ENGINEER DISTRICT, BUFFALO



PROFILE



STATION 1100+00 TO STATION 1150+00

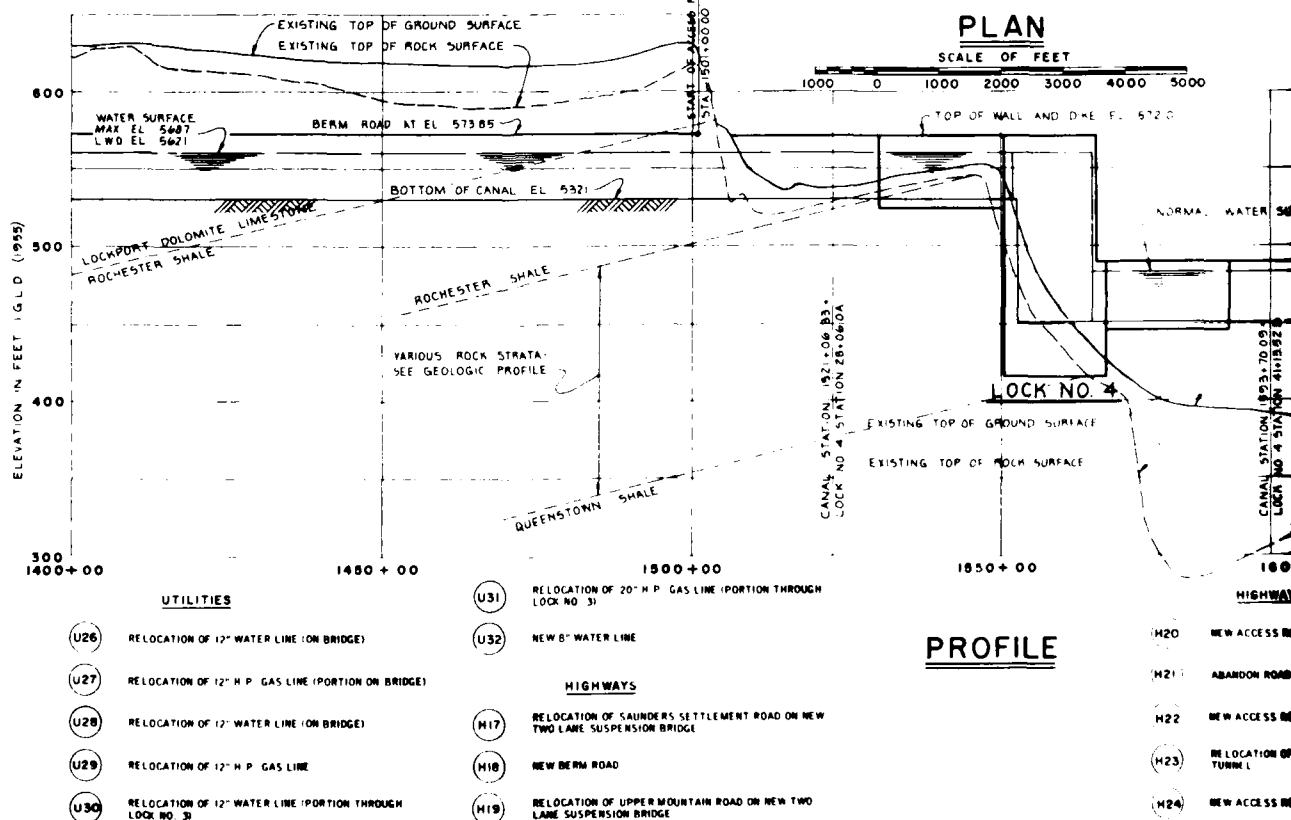
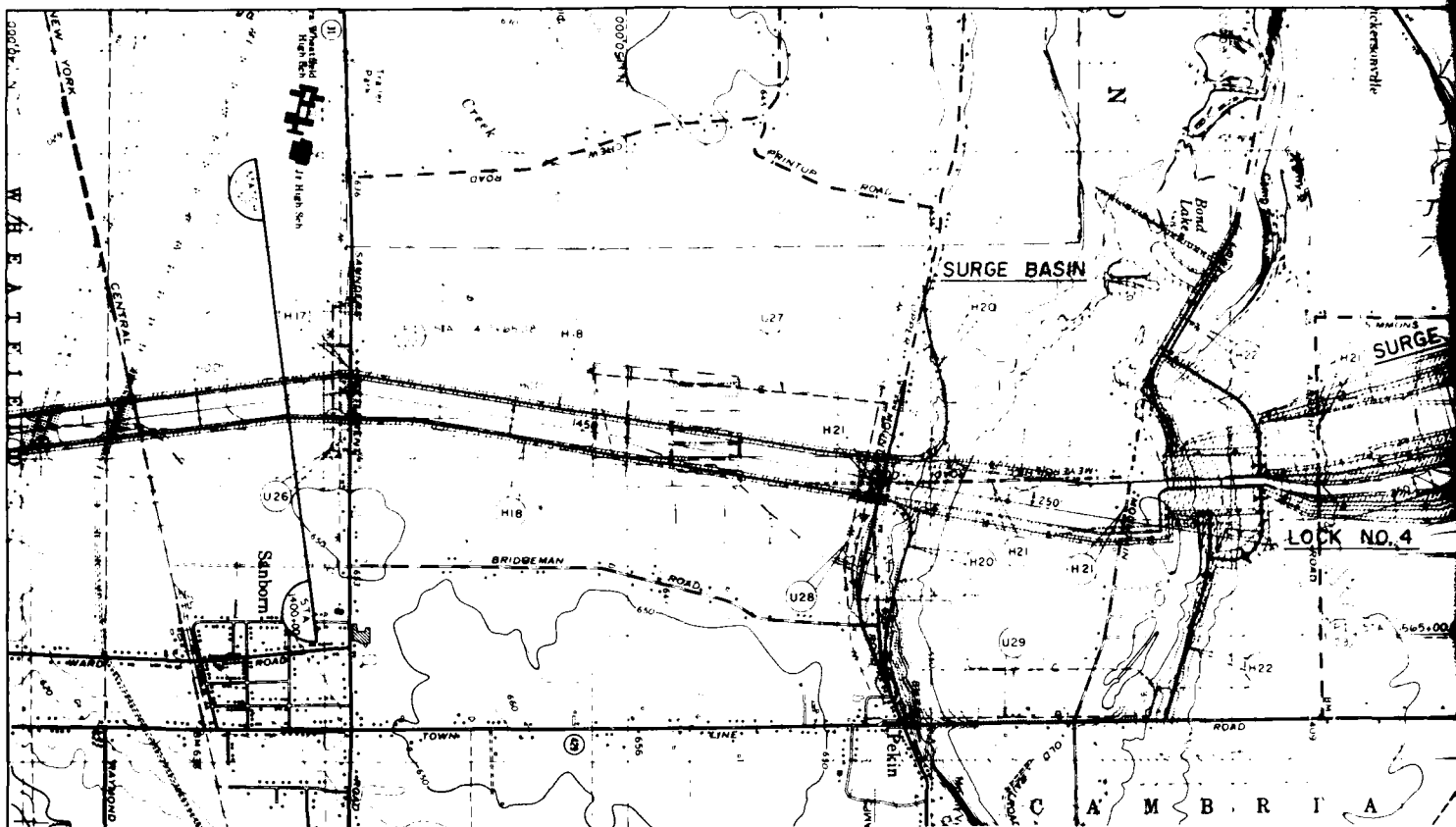


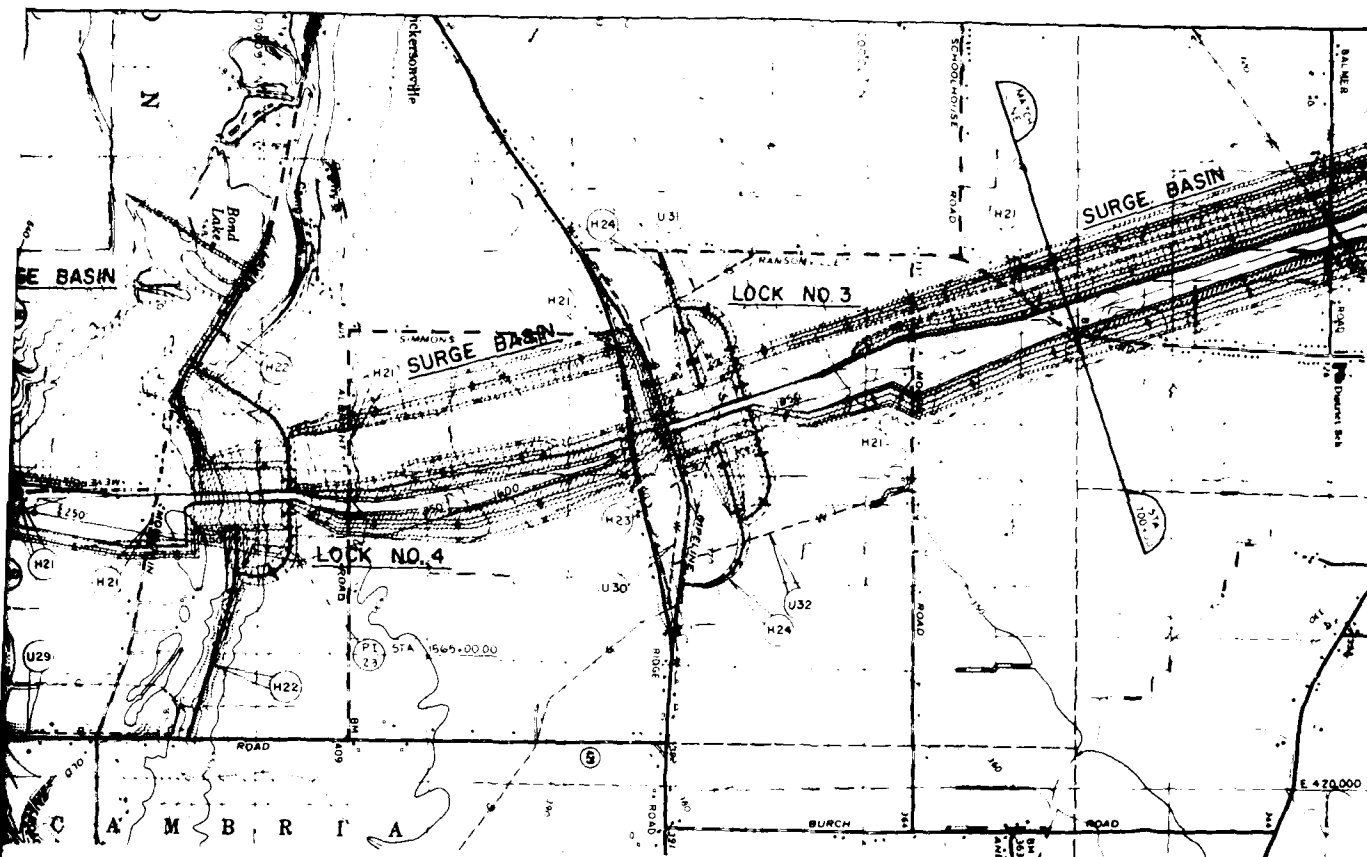
PROFILE

LAKE ERIE-LAKE ONTARIO WATERWAY PROFILE AND SECTIONS STA. 1100+00 TO 1400+00

SCALE AS SHOWN

U. S. ARMY ENGINEER DISTRICT, BUFFALO

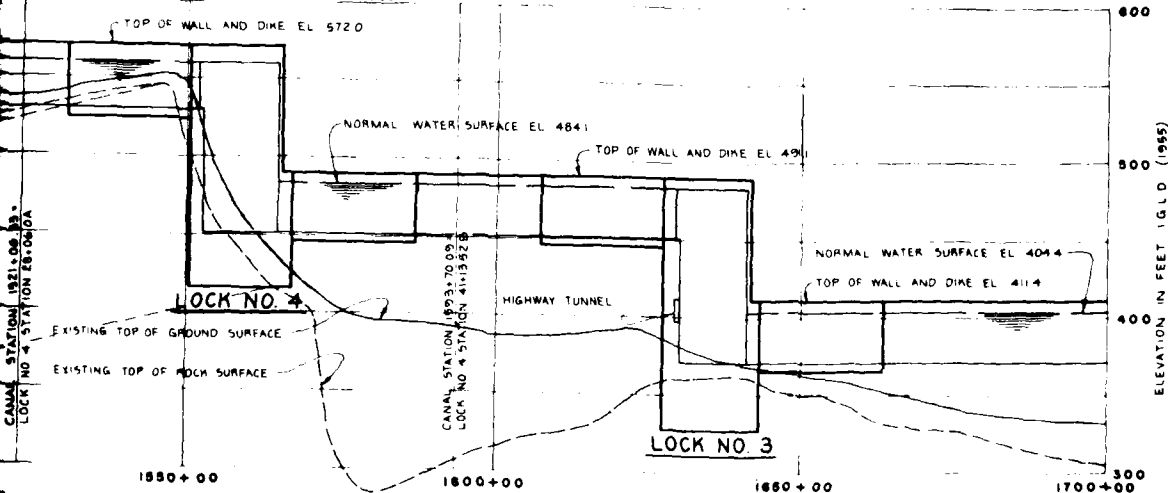




PLAN

SCALE OF FEET

0 1000 2000 3000 4000 5000



PROFILE

- (H20) NEW ACCESS RAMP TO BERM ROAD
- (H21) ABANDON ROAD
- (H22) NEW ACCESS ROAD TO LOCK NO. 4
- (H23) RELOCATION OF RIDGE ROAD THROUGH NEW TWO LANE TUNNEL
- (H24) NEW ACCESS ROAD TO LOCK NO. 3

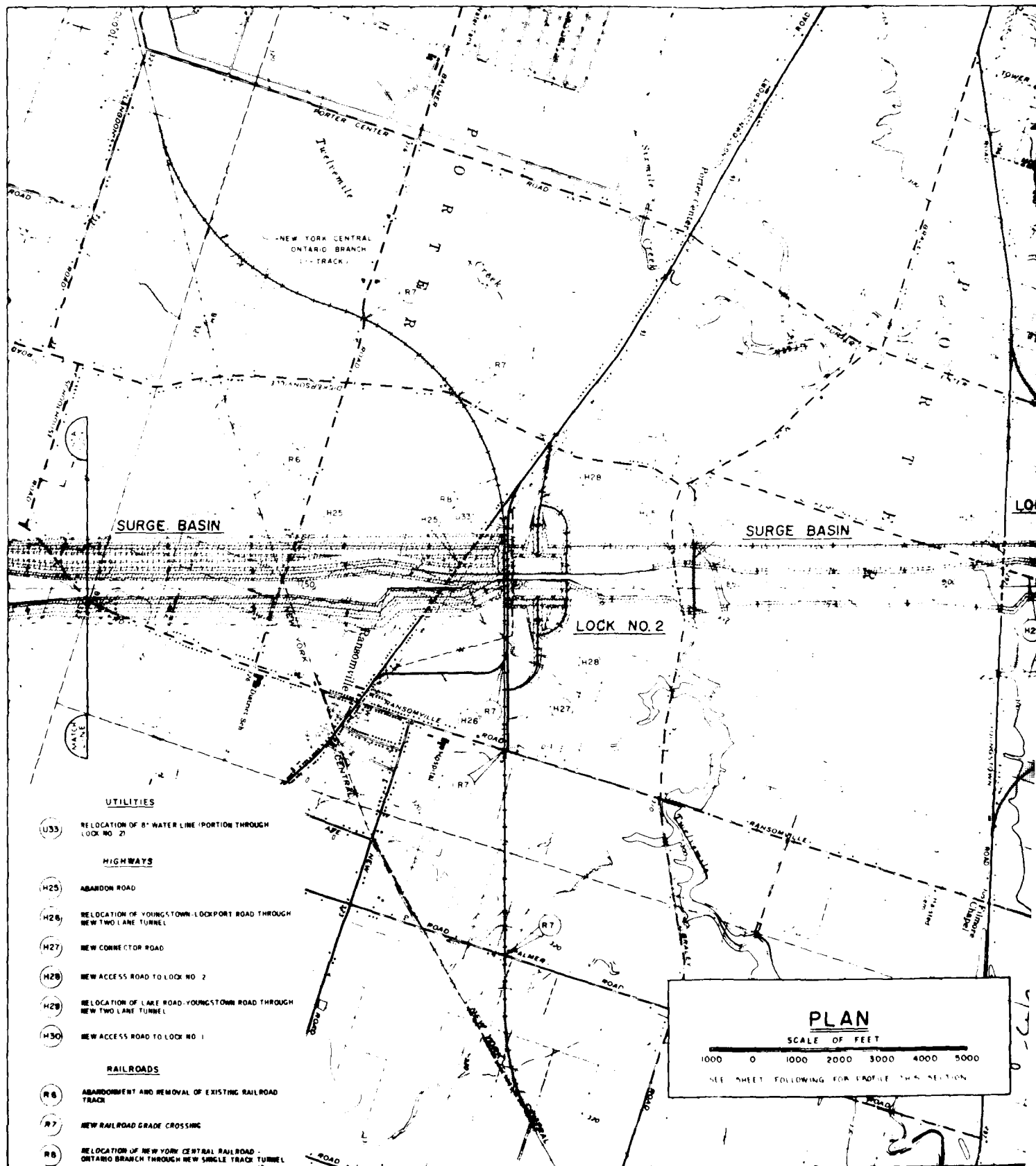
LAKE ERIE-LAKE ONTARIO WATERWAY

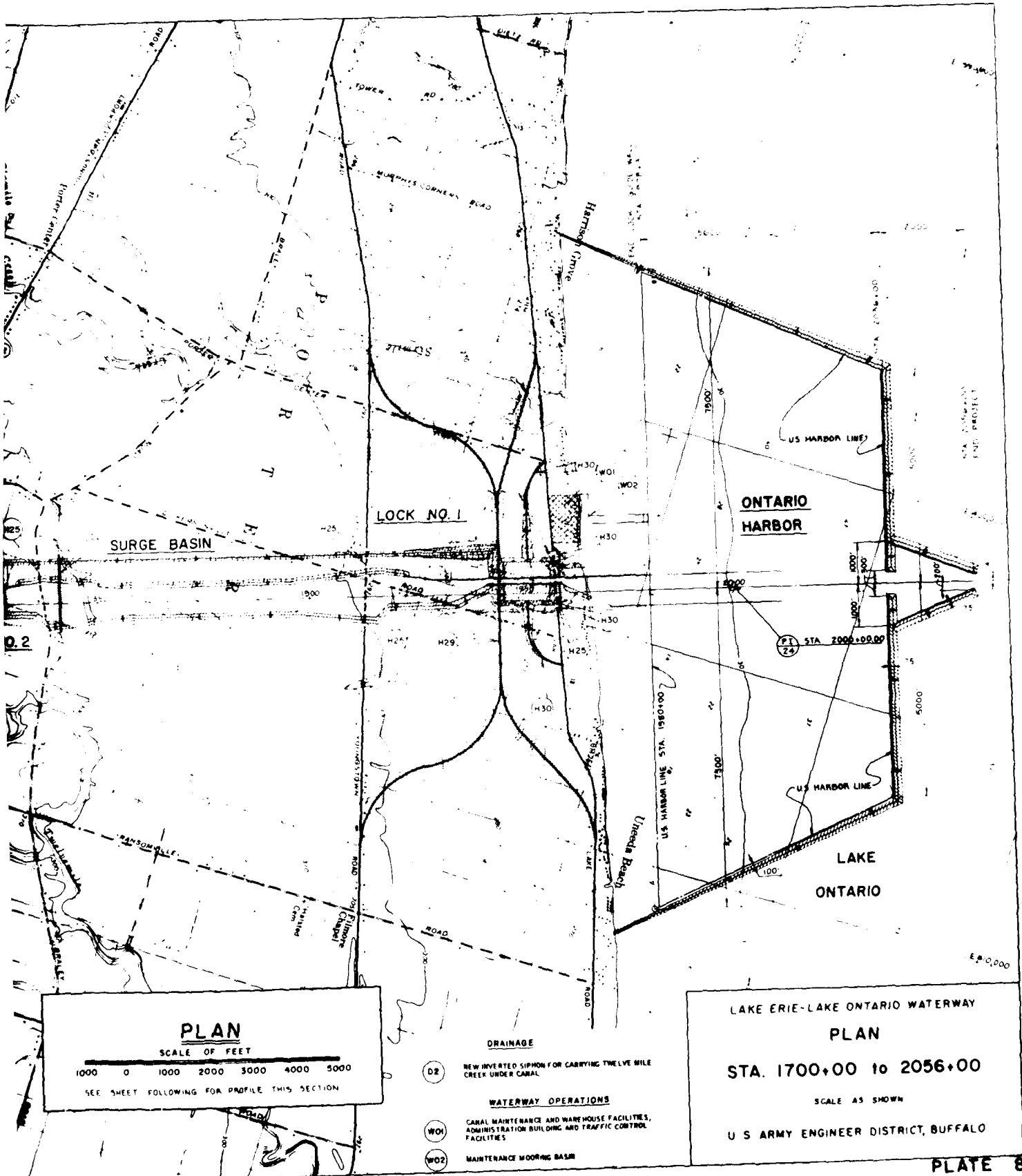
PLAN AND PROFILE

STA. 1400+00 to 1700+00

SCALE AS SHOWN

U S ARMY ENGINEER DISTRICT, BUFFALO





PLAN

SCALE OF FEET

1000 0 1000 2000 3000 4000 5000

SEE SHEET FOLLOWING FOR PROFILE THIS SECTION

DRAINAGE

(D2) NEW INVERTED SIPHON FOR CARRYING TWELVE MILE CREEK UNDER CANAL

WATERWAY OPERATIONS

(W01) CANAL MAINTENANCE AND WAREHOUSE FACILITIES, ADMINISTRATION BUILDING AND TRAFFIC CONTROL FACILITIES

(W02) MAINTENANCE MOORING BASIN

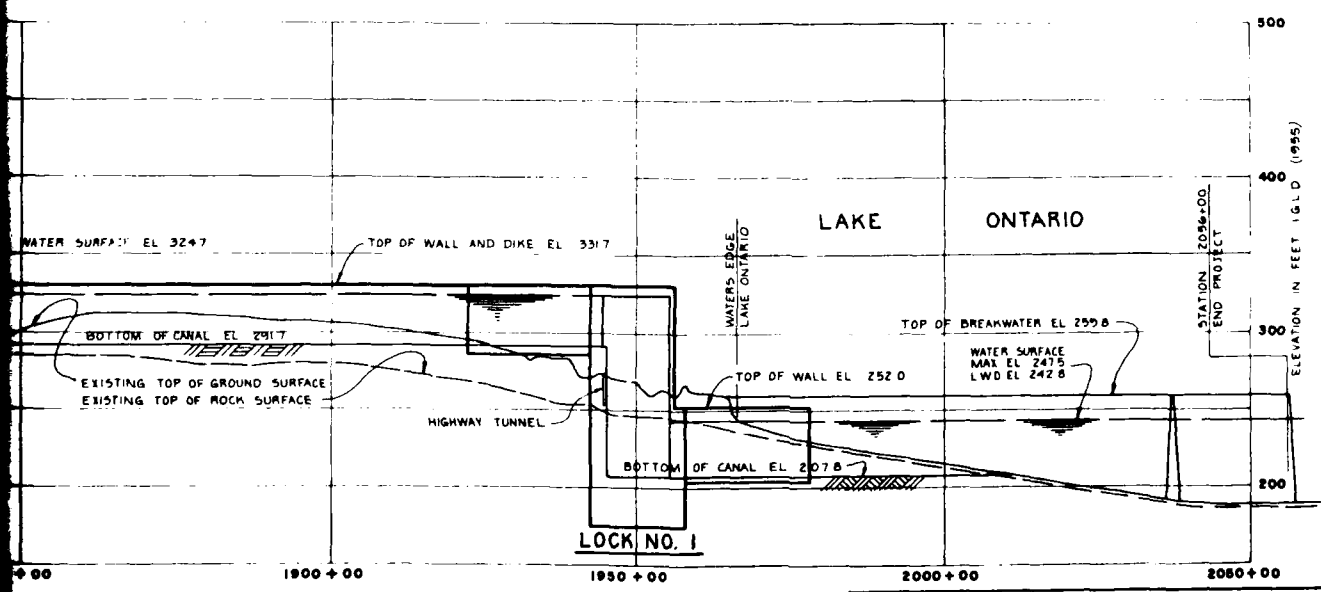
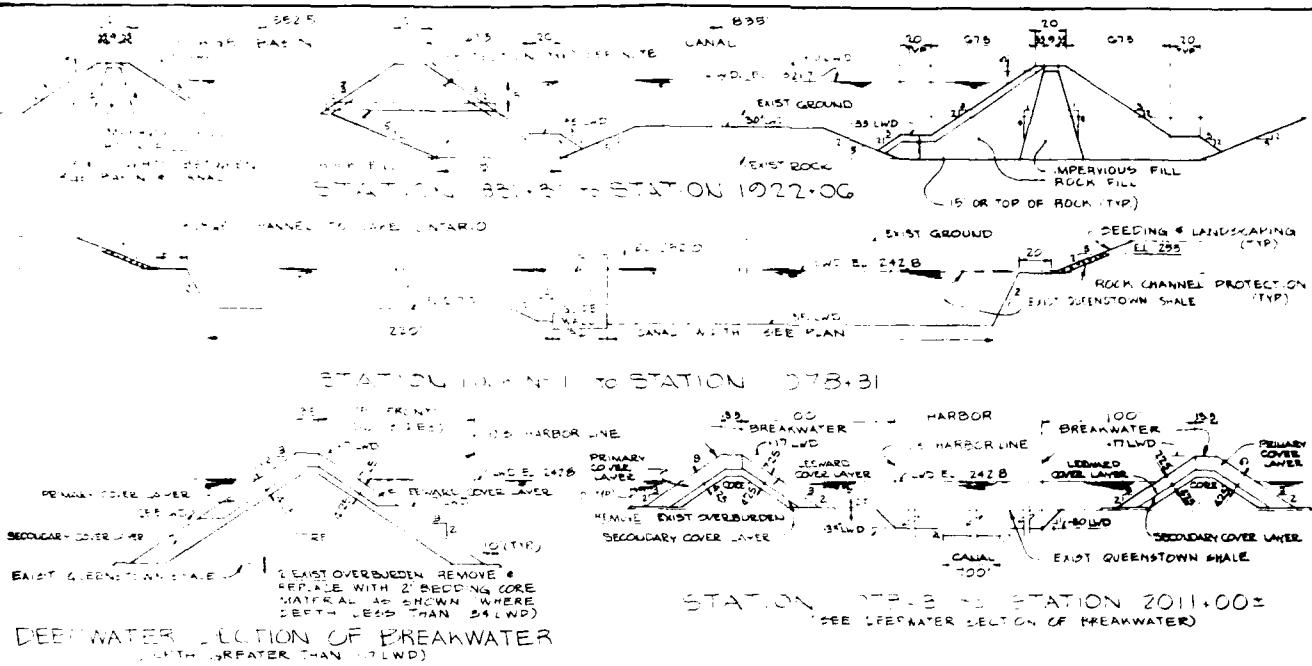
LAKE ERIE-LAKE ONTARIO WATERWAY

PLAN

STA. 1700+00 to 2056+00

SCALE AS SHOWN

U S ARMY ENGINEER DISTRICT, BUFFALO

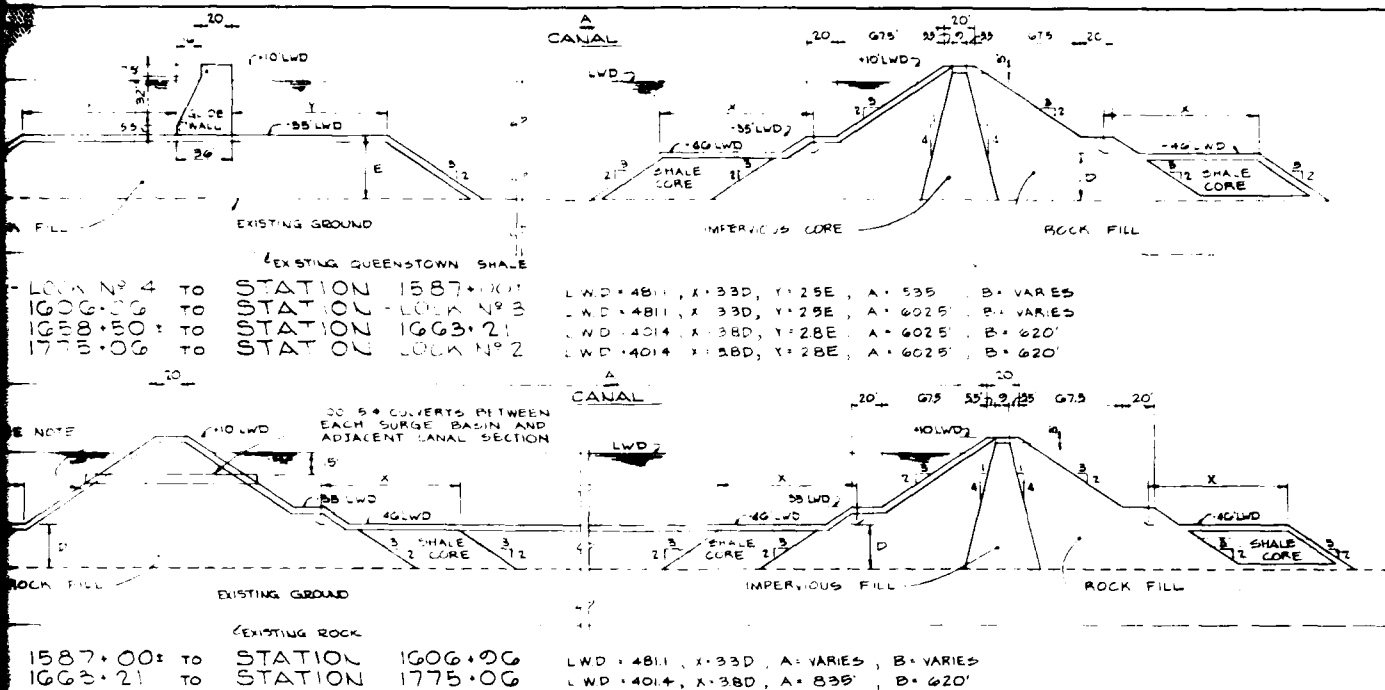


PROFILE

LAKE ERIE-LAKE ONTARIO WATERWAY
PROFILE AND SECTIONS
STA. 1700+00 to 2056+00

SCALE AS SHOWN

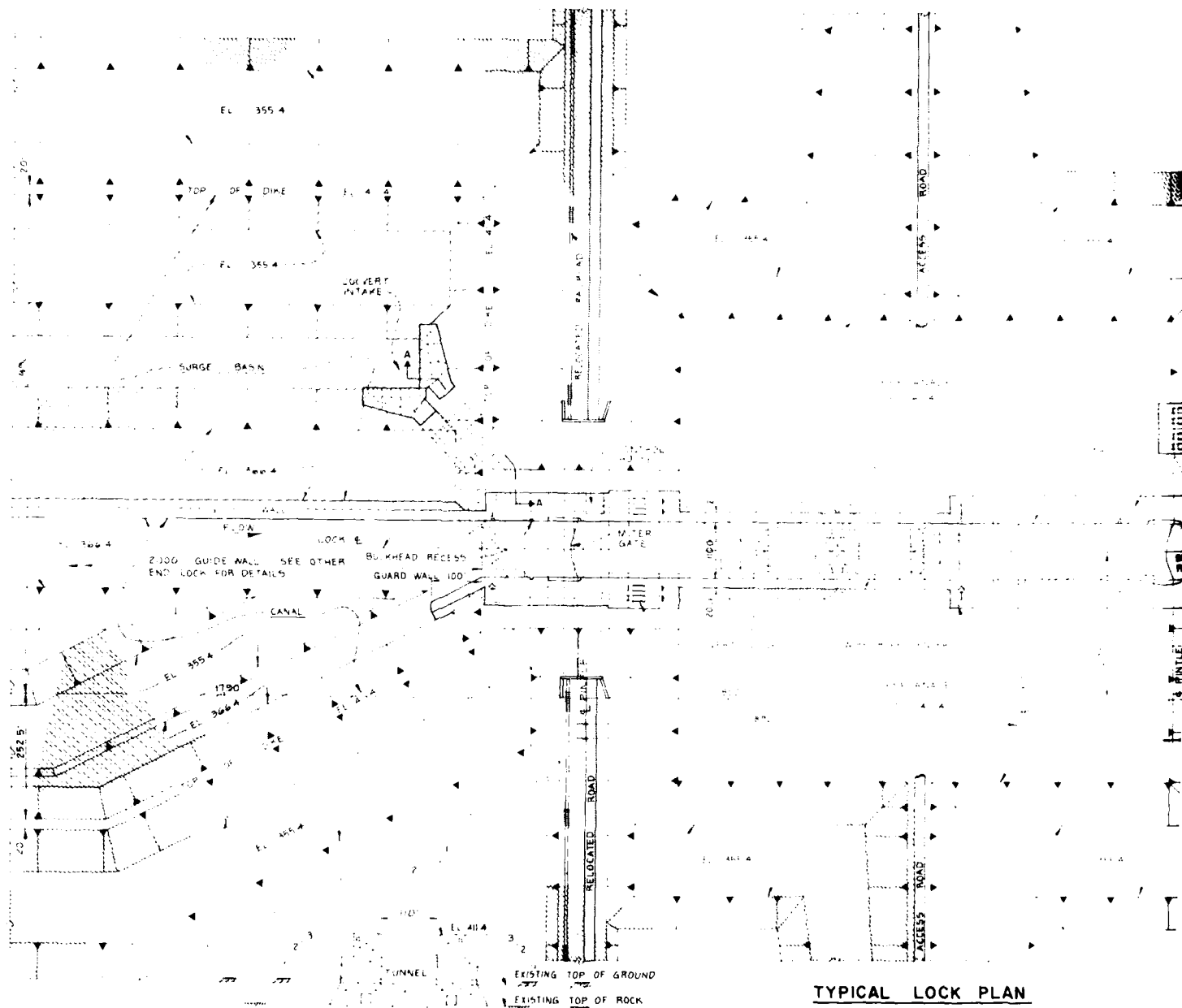
U. S. ARMY ENGINEER DISTRICT, BUFFALO



LAKE ERIE-LAKE ONTARIO WATERWAY SECTIONS

SCALE AS SHOWN

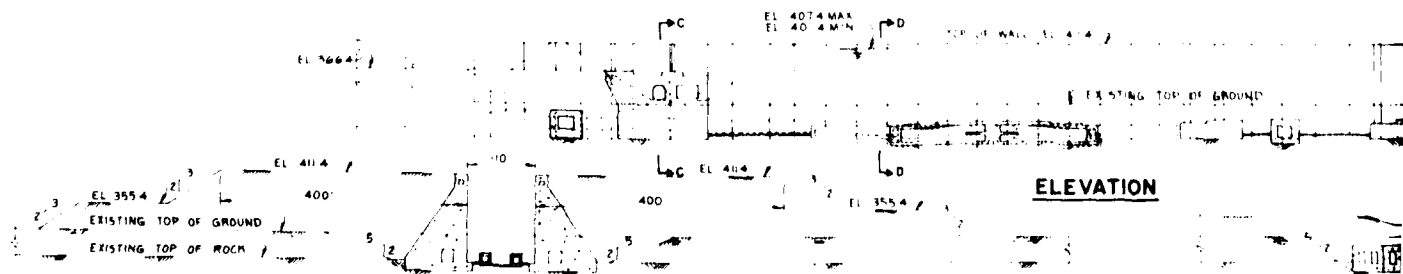
U. S. ARMY ENGINEER DISTRICT, BUFFALO



TYPICAL LOCK PLAN

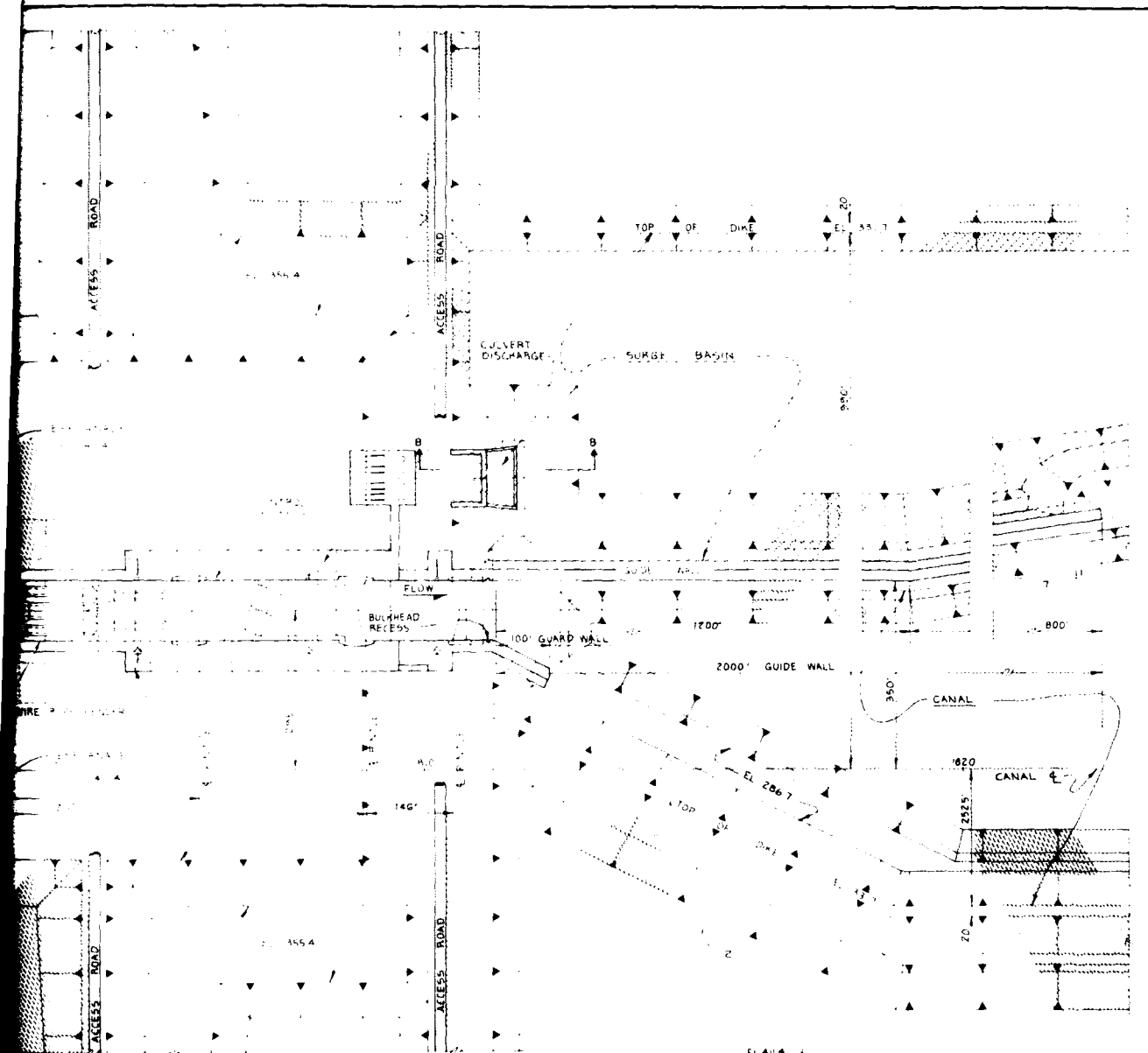
IF NO. 2 AT SHOWN LOCKS ARE SIMILAR
LOCK NO. 4 HAS NO TUNNEL

SECTION C C



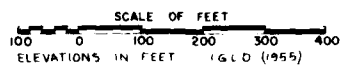
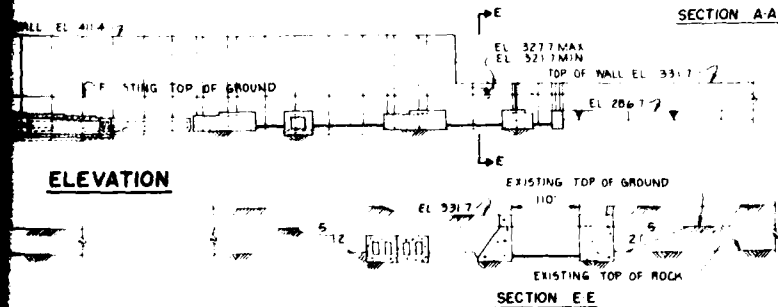
ELEVATION

SECTION D D



TYPICAL LOCK PLAN

2 AS SHOWN, LOCKS 1,3&4 SIMILAR.
 4 HAS NO TUNNEL

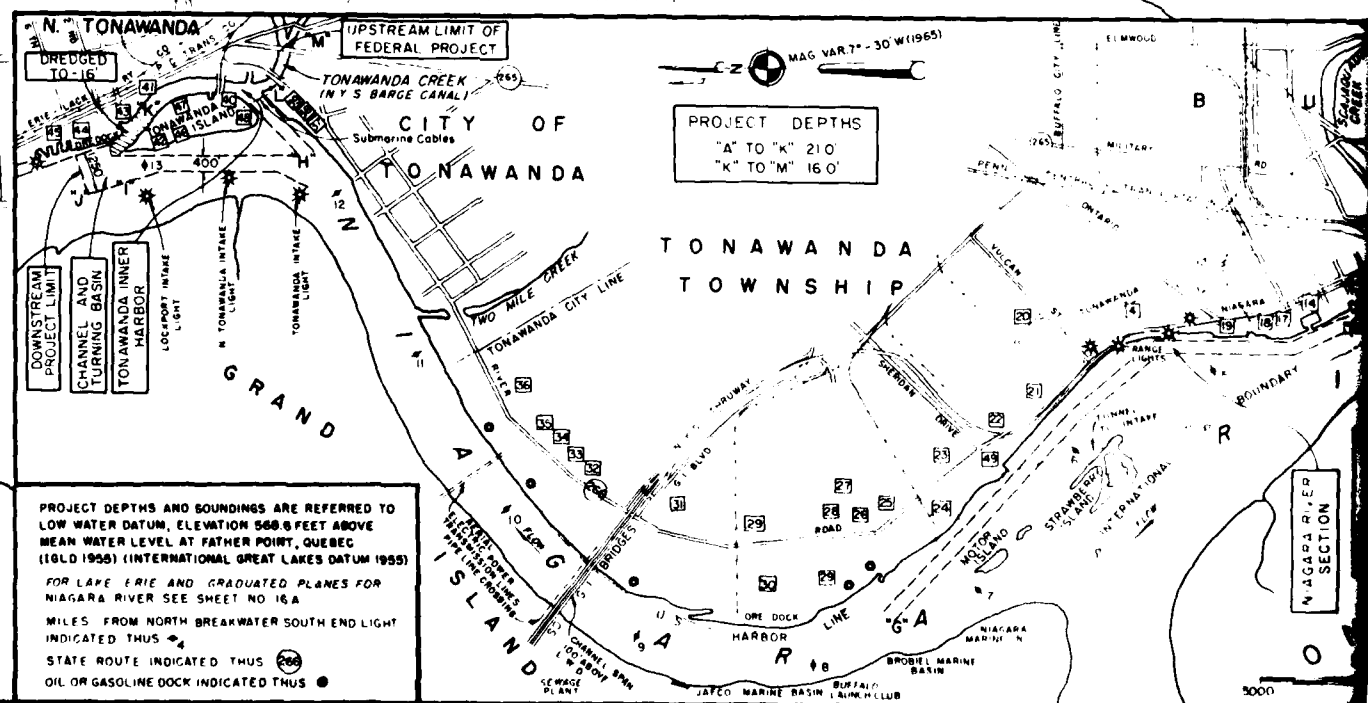
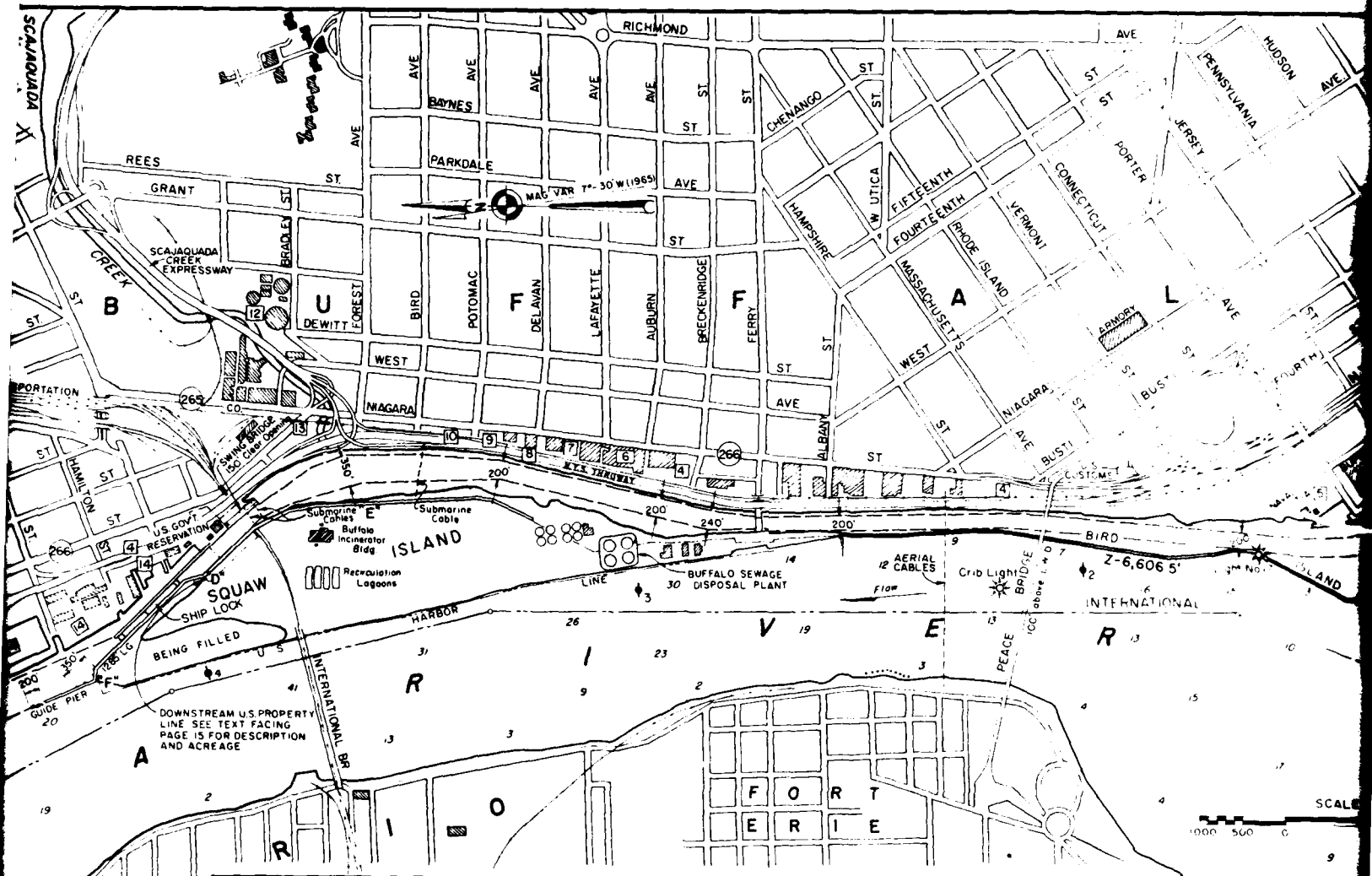


LAKE ERIE-LAKE ONTARIO WATERWAY

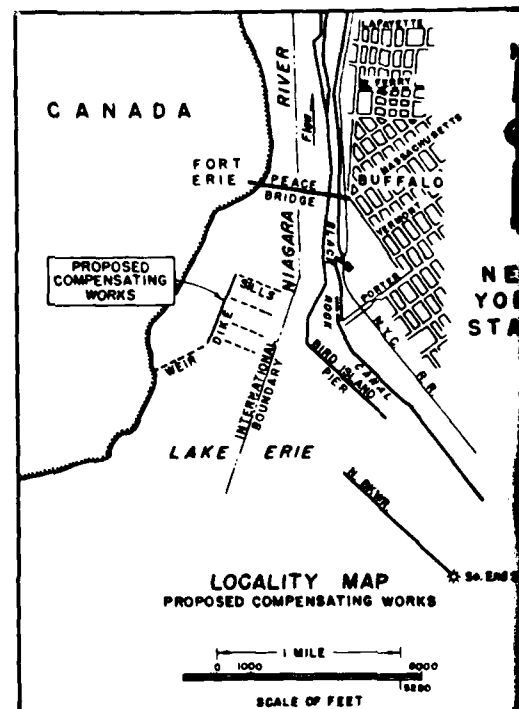
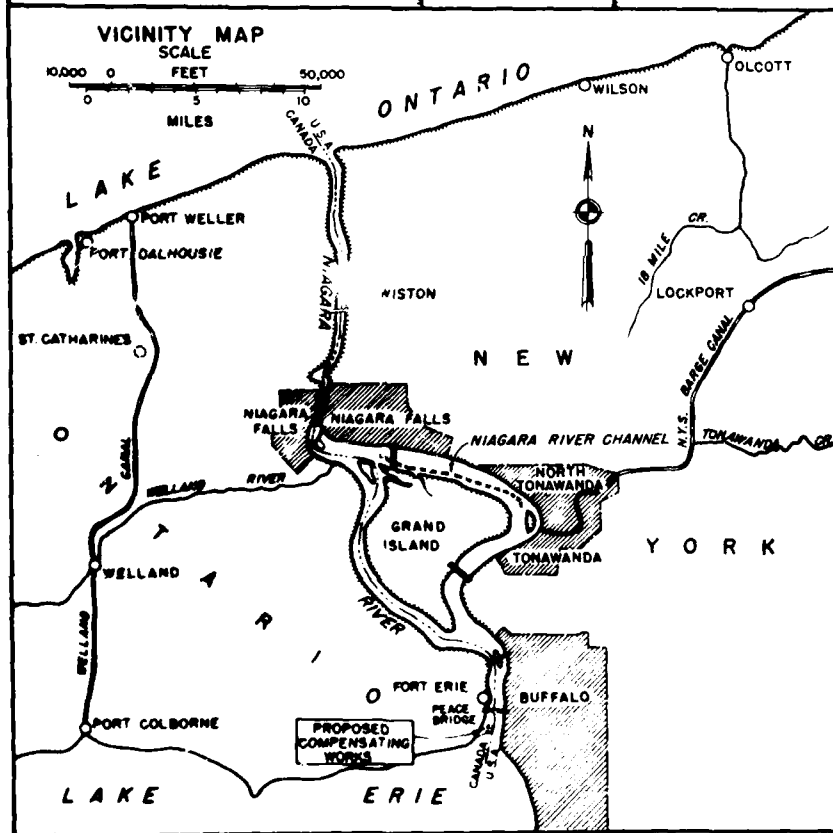
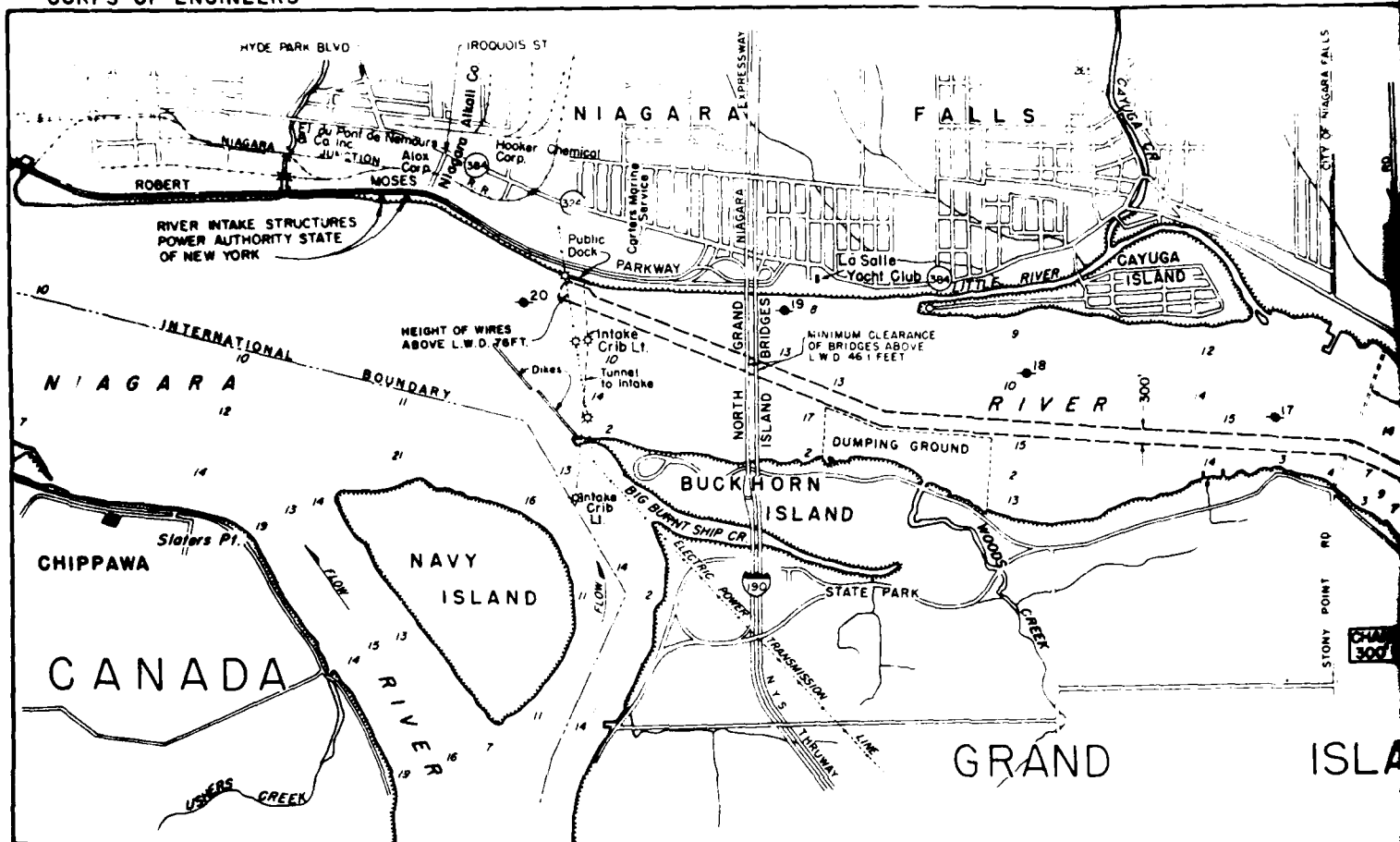
TYPICAL LOCK PLAN AND DETAILS

SCALE AS SHOWN

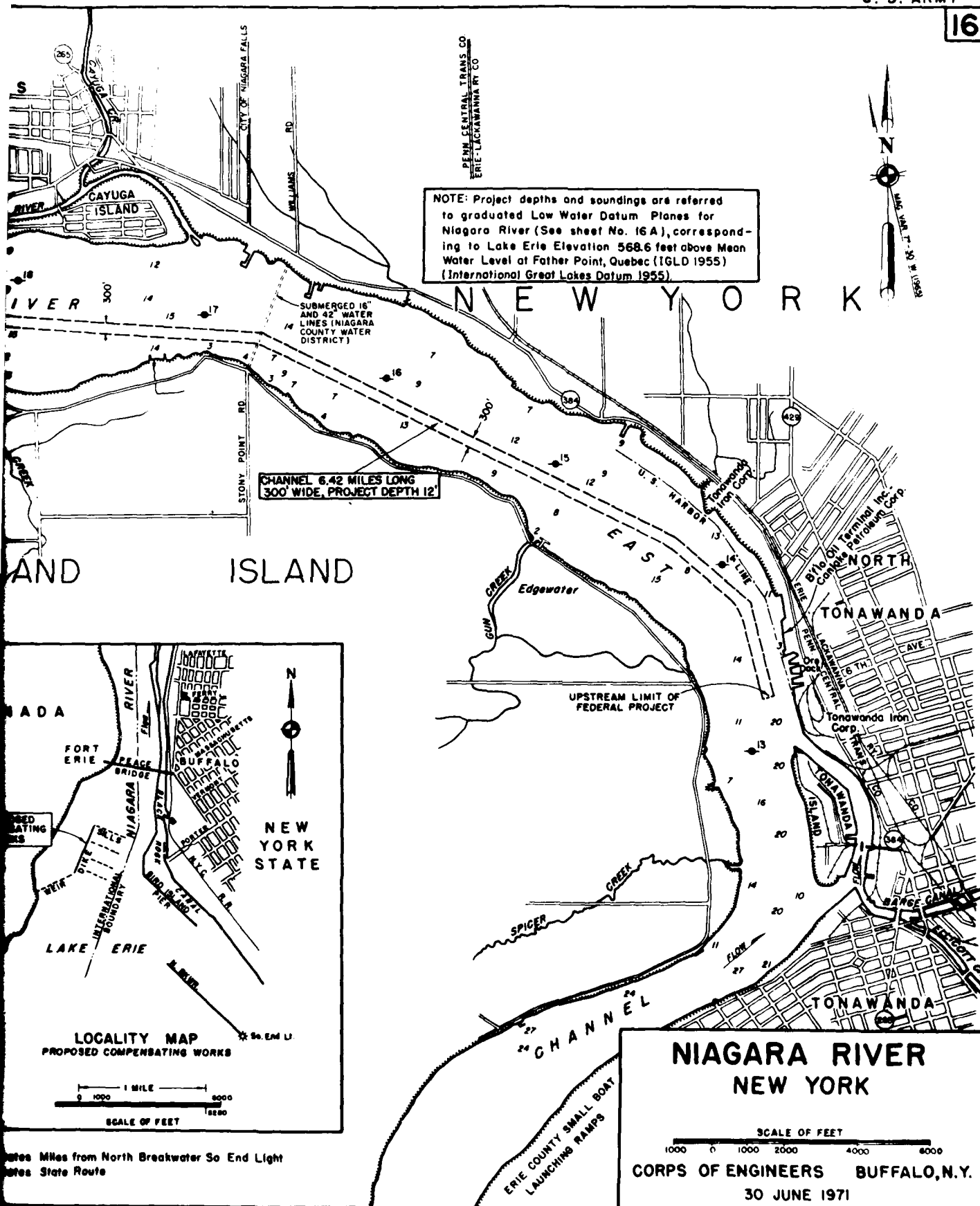
U. S. ARMY ENGINEER DISTRICT, BUFFALO



CORPS OF ENGINEERS



NOTES:
 13 = Indicates Miles from North Breakwater So End Light
 240 = Indicates State Route



END

DATE
FILMED

7-18-11

DTIC